DEPARTMENT OF ENVIRONMENTAL REGULATION

ROUTING AND TRANSMITTAL SLIP

ACTION NO

ACTION DUE DATE

1. TO: (NAME, OFFICE, LOCATION)	
[redacted]	INITIAL / DATE
2. [redacted] GEORGE [redacted]	INITIAL / DATE
3. [redacted]	INITIAL / DATE
4. Cindy	INITIAL / DATE

REMARKS:

File - PSD-FL-029

INFORMATION

- [ ] REVIEW & RETURN
- [ ] REVIEW & FILE
- [ ] INITIAL & FORWARD

DISPOSITION

- [x] REVIEW & RESPOND
- [ ] PREPARE RESPONSE
- [ ] FOR MY SIGNATURE
- [x] FOR YOUR SIGNATURE
- [ ] LET'S DISCUSS
- [ ] SET UP MEETING
- [ ] INVESTIGATE & REPT
- [ ] INITIAL & FORWARD
- [ ] DISTRIBUTE
- [ ] CONCURRENCE
- [ ] FOR PROCESSING
- [ ] INITIAL & RETURN

FROM: STEVE SMALLWOOD [signature]

DATE 4-10-81

PHONE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET
ATLANTA, GEORGIA 30365

APR 1981
RECEIVED
BUREAU
AQM

APR 3 1981

REF: 4AH-AF

Mr. Steve Smallwood, Chief
Bureau of Air Quality Management
Florida Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, Florida 32301

Re: St. Regis Paper Company
Proposed Permit Application
Modification - Pulp Plant Expansion
PSD-FL-029 - Issued December 11, 1979

Dear Mr. Smallwood:

Enclosed for your review and comment are the Public Notice and St. Regis submittals of January 7 and 12, 1981 requesting design modifications to their previously permitted pulp plant expansion. The public notice will appear in a local newspaper, Pensacola News-Journal, in the near future.

Please refer any comments or questions regarding this request to my staff. You may contact Dr. Kent Williams, Chief, New Source Review Section, at 404/881-4552.

Sincerely yours,

K Williams
acting for
Tommie A. Gibbs
Chief
Air Facilities Branch

Enclosure

Public Notice
PSD-FL-029

The St. Regis Paper Company, located near the City of Cantonment in Escambia County, Florida, has requested to make two design modifications to their previously permitted expansion (October 11, 1979). The first design modification includes incineration of reduced sulfur compounds from the digester washer system vent and black liquor evaporation vent instead of no control and continuous monitoring as originally required by permit. The second modification involves the use of a pneumatic system and recovery cyclone for conveying and recovery of chip fines from the rechipper to the bark boiler in lieu of a belt conveying system.

Increases of sulfur dioxide from the incineration of odorous reduced sulfur compounds will be less than one ton per year. Particulate emission increases from the recovery cyclone on the proposed chip fines handling system are estimated to be six tons per year.

The request for a construction permit application modification has been reviewed by the U. S. Environmental Protection Agency. The modifications will affect no previously issued permit emissions limitation nor significantly impact air quality. EPA has, therefore, made the determination that the proposed design modifications may be incorporated into the August 29, 1979 construction permit application, and facilities built in accordance with this application as recommended under Prevention of Significant Deterioration permit FL-029 issued October 11, 1979.

A summary of the basis for this determination submitted by the St. Regis Paper Company is available for public review in the office of Mr. Joe A. Flowers, County Comptroller, Escambia County, corner of Palafox and Government Streets, Pensacola, Florida.

Any person may submit written comments to EPA regarding the proposed changes. All substantive comments, postmarked no later than 30 days from the date of this notice, will be considered by EPA and be made part of the official record. Letters should be addressed to:

Mr. Tommie A. Gibbs, Chief
Air Facilities Branch
U.S. Environmental Protection Agency
345 Courtland Street
Atlanta, Georgia 30365

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET
ATLANTA, GEORGIA 30365

GOVERNOR'S OFF
Planning and Budgeting
Intergovernmental Co
APR 9 1981
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MAY 1981
RECEIVED
BUREAU
A Q M

APR 3 1981

REF: 4AH-AF

DCH
DFR
DHDS
LD

Ms. Carolyn Dekle
State A-95 Coordinator
Florida State Planning and
Development Clearinghouse
Office of Planning and Budget
The Capitol
Tallahassee, FL 32301

Re: St. Regis Paper Company
Proposed Permit Application
Modification
Pulp Plant Expansion
Permit PSD-FL-029 - Issued December 11, 1979

811273

Dear Ms. Dekle:

I wish to bring to your attention that the St. Regis Paper Company has requested to modify their construction plans for a previously permitted expansion at their papermill near the town of Cantonment, Florida. Emissions increases of sulfur compounds and TSP will be insignificant. The U. S. Environmental Protection Agency (EPA) has reviewed their proposed construction modifications and has reached a determination of approval.

Please also be aware that the attached public notice announcing the Agency's determination, the availability of pertinent information for public scrutiny, and the opportunity for public comment will be published in a local newspaper, Pensacola News-Journal, in the near future. This notice has been mailed to you for your information. You need take no action unless you wish to comment on the proposed design changes.

If you have questions, please feel free to call Dr. Kent Williams, Chief, New Source Review Section, at 404/881-4552.

Sincerely yours,

K Williams
acting for
Tommie A. Gibbs
Chief
Air Facilities Branch

Enclosure

RECEIVED
APR 14 1981
DIV. ENVIRONMENTAL PERMITTING

Public Notice
PSD-FL-029

The St. Regis Paper Company, located near the City of Cantonment in Escambia County, Florida, has requested to make two design modifications to their previously permitted expansion (October 11, 1979). The first design modification includes incineration of reduced sulfur compounds from the digester washer system vent and black liquor evaporation vent instead of no control and continuous monitoring as originally required by permit. The second modification involves the use of a pneumatic system and recovery cyclone for conveying and recovery of chip fines from the rechipper to the bark boiler in lieu of a belt conveying system.

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Mr. Tommie A. Gibbs, Chief
Air Facilities Branch
U.S. Environmental Protection Agency
345 Courtland Street
Atlanta, Georgia 30365

DEPARTMENT OF ENVIRONMENTAL REGULATION

ROUTING AND TRANSMITTAL SLIP

ACTION NO		
ACTION DUE DATE		

1. TO: (NAME, OFFICE, LOCATION)	Initial / Date
1. MIKE HARLEY	Initial Date
2. BAQM	Initial Date
3. DER	Initial Date
4. TALLAHASSEE	Initial Date

REMARKS:

You can keep these. They are copies.

DO NOT KEEP THE BACT APPLICATION (construction permit application) SEPARATE

DER

OCT 14 1987

BAQM

INFORMATION

	Review & Return
	Review & File
	Initial & Forward

DISPOSITION

	Review & Respond
	Prepare Response
	For My Signature
	For Your Signature
	Let's Discuss
	Set Up Meeting
	Investigate & Report
	Initial & Forward
	Distribute
	Concurrence
	For Processing
	Initial & Return

FROM: Joe

DATE Oct 12 1987

PHONE

ES

ENGINEERING-SCIENCE

7903 WESTPARK DRIVE · McLEAN, VIRGINIA 22102 · 703 790-9300

CABLE ADDRESS: ENGINSC.
TELEX 89-9401

January 13, 1981
3165.50/50

Mr. Thomas W. Moody
Florida Department of
Environmental Regulations
160 Governmental Center
Pensacola, FL 32501

Re: Modification to St. Regis Paper Mill Expansion Permit (AC/7-21829)

Dear Tom:

On October 10, 1979 you issued St. Regis Paper Company a permit to modify the Pensacola Mill to increase production of pulp and paper. We would like to modify the material handling system for the chips and the incineration method for the noncondensable gas system. In addition, we wish to eliminate two TRS sources by now including these emissions into the noncondensable gas system.

When I talked with you on January 7, 1981, you indicated that it would not be necessary to amend our permit since we do not plan to increase emissions by more than 10% of the amount already permitted. We wanted to advise you of our changes and document our calculations showing the change in emissions. We have already met with EPA in Atlanta and discussed the changes with them.

Chip Handling System

We originally proposed to use a belt conveyor system to move all of the wood chips from the chipper area to the digesters. Wood chips, both pine and hardwoods, are first screened and then conveyed by belt to the existing chip silo or the new No. 5 Silo. The oversized chips are processed through the No. 3 rechipper and subsequently conveyed to the chip silos. (A fact sheet on a rechipper is enclosed.) The undersized chips, are commonly called "chip fines" and are normally burned in the bark boiler. The construction engineers advise us that it is more economical to use a blower system on the rechipper and a pneumatic handling system for the chip fines rather than a belt conveyor system. The size of the chips from the rechipper will be about a 1-1/4-inch square. Chip fines are those which pass through the screen and are smaller than chips used for pulp. A pneumatic system is currently used at the mill to transport chips to the No. 1 Pulp Mill. The chips are fairly wet and contain between 40 and 60 percent water. There are no visible emissions from this cyclone. With a pneumatic system, cyclones are used to separate the chip fines from the air. Some particles may be entrained and exhausted to the atmosphere, thus becoming a new source of air pollution. The belt conveyor system did not discharge any TSP to the atmosphere and was, therefore, not considered in the PSD analysis as a source.

Three new cyclones are now proposed to handle about 5% of the chips for the new mill. The other 95% will be handled with the belt conveyor system. Two cyclones will be used on the rechipper which handles normal size chips. The flow rate on these units are 5,000 cfm each. A smaller unit (1650 cfm) will be used for the chip fines. This material will be smaller than the 1-1/4-inch nominal chip. We do not have data on size distribution of the chip fines. This material is unlike woodworking fines from sanding or sawing operations but we have included portions of the AP-42 write-up on this subject. St. Regis is not screening chips at their existing mills.

This past summer, St. Regis made tests on a similar chip handling system at their Lumber City, Georgia plant. EPA stack test methods were followed. A special hood system was developed to place on the end of the cyclone so that the "cyclonic flow" in the stack was eliminated. The emissions from one unit were .013 gr/dscf and .003 gr/dscf for the second unit. ES also obtained data from EPA (Durham) on Canadian mills for three different plants for handling chips. A copy of this data is enclosed. The emissions were .001, .006, and .015 gr/dscf. If you consider the chips as the inlet loading to the cyclone, which is also used as an air pollution abatement device, the removal efficiency is greater than 99.9%. We have tried to secure other data on chip fine emissions from other state agencies and trade associations, but little information was available. We have attached a list of the contacts we made in trying to secure additional data.

As a worst case estimate of the TSP emissions from the three cyclones, ES used the St. Regis Lumber City data to determine the additional loading. We used the 0.013 gr/dscf loading for all cyclones. We believe this to be conservative since most of the flow rate capacity of these cyclones will handle chips from the rechipper, i.e., the 1-1/4-inch material. Using this data, the additional TSP emissions are 6 tpy. With this grain loading at the stack, there will not be any visible emissions from these three units.

The design of these cyclones will include the necessary supporting structure to add a baghouse, in the event that visible emissions do occur for these processes. We believe this to be a minor source of TSP that will not effect the TSP air quality levels or PSD increments in this area.

Noncondensable Gas System

In our original application we proposed to incinerate the exhaust gas from the noncondensable gas system in the new calciner because it contained TRS compounds. The design engineers believe it to be advantageous, from an operations viewpoint, to have the TRS emissions incinerated in the new calciner and/or the existing lime kiln. In other words, we now seek permission to burn the TRS in the old kiln in addition to the new calciner. The existing noncondensable gas system exhausts into the existing lime kiln. Either the kiln or the calciner are capable of destroying the TRS because they both have a high operating temperature. The lime kiln has the higher temperature. At the combustion zone the temperature will be about 2300-2600°F and at the lime mud addition end, the temperature will be about 390-600°F. The calciner operates at 1600-1650°F. Retention time of the TRS would also be greater in the existing kiln than the new calciner. Furthermore, both the kiln and the calciner will remove SO_2 because of the presence of the lime.

We also propose to eliminate the minor TRS emission sources Vents I and II, in our application. The design engineers have developed a simple method for including any emissions from the diffusion washer (Vent I) and the washer filtrate tanks (Vent II) into the noncondensable gas system. The cost of TRS monitors on these vents exceeds the cost for replumbing these two vents into the noncondensable gas system and the kiln/calciner. The TRS emissions from each vent were .009 lb/hr. The TRS will be burned and an additional .148 tpy of SO_2 will be generated. However, most of the SO_2 is captured in the kiln/calciner lime or in the wet scrubber which follows.

<u>Summary</u>

The construction engineers have recommended some improvements in the operation of the new paper mill which differ from the concept outlined in the priliminary design which was used in the PSD application. A slight increase in TSP emissions (<10 tpy) is now being proposed because of a change in the chip handling system. An alternate method to eliminate TRS in the noncondensable gas system is being proposed. Two TRS vents will be eliminated. No changes in emissions from other pollutants from our original submittal will occur.

Please advise us if you need any further information on these modifications.

Very truly yours,

ENGINEERING-SCIENCE

Mike

Michael E. Lukey, P.E.
Vice President

MEL/ch

cc: Don Ferguson
Frank Westmark
Russ Hudson

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

St. Regis Paper Company
Escambia County
Fluo-Solids Unit #1

CONSTRUCTION PERMIT

NO. AC17-21829

DATE OF ISSUANCE

October 10, 1979

Robert V. Kriegel
District Manager

DATE OF EXPIRATION

April 1, 1983

DER FORM PERM 11-42

10-17-0042-36

160 GOVERNMENTAL CENTER
PENSACOLA, FLORIDA 32501

BOB GRAHAM
GOVERNOR

JACOB D. VARN
SECRETARY

ROBERT V. KRIEGEL
DISTRICT MANAGER

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

NORTHWEST DISTRICT

October 10, 1979

APPLICANT:

St. Regis Paper Company

CONSTRUCTION PERMIT/CERTIFICATION NO. AC17-21829

COUNTY: Escambia

PROJECT: Fluo-Solids Unit #1

This permit is issued under the provisions of Chapter 403, Florida Statutes, and Chapter 17-2 and 17-4, Florida Administrative Code. The above named applicant, hereinafter called Permittee, is hereby authorized to perform the work or operate the facility shown on the approved drawing(s), plans, documents, and specifications attached hereto and made a part hereof and specifically described as follows:

A system with three major connected elements:

1. A Kamyr continuous digester and washing system with [two small uncontrolled vents (I and II), and all other] emissions fed to the condensate stripper.

2. A condensate stripper with all noncondensable emissions fed to the calciner to incinerate reduced sulfur.

3. A fluidized bed calciner. Sulfur emissions are controlled by incineration and reaction with lime. Particulates are controlled by a venturi wet scrubber.

Located at: Muscogee Road, Cantonment.

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions:, and as such are binding upon the permittee and enforceable pursuant to the authority of Section 403.161(1), Florida Statutes. Permittee is hereby placed

PERMIT NO.: AC17-21829
APPLICANT: St. Regis Paper Company

14. The Department shall be notified within 15 days after construction is completed and prior to testing to allow witnessing of tests.

15. Particulate and TRS stack test results are required to show compliance with standards of the Department and shall be considered in review of the application for an operating permit. The test results shall show compliance at the desired operating conditions.

16. A certificate of completion (form attached) shall be submitted, with the compliance stack test results, as an application for an operating permit. These are to be submitted within 60 days after completion of construction.

17. Adequate ladders, platforms, necessary sampling ports, and safety devices shall be provided as necessary for stack sampling.

18. All fugitive dust generated at this site shall be adequately controlled.

19. In accordance with BACT determination the TRS emissions from the calciner shall not exceed 8 ppm by volume and the particulates shall not exceed 0.067 grains/dry standard cubic foot (both with oxygen content corrected to 10%).

20. Emissions from Vent I must be less than 5 ppm on dry basis corrected to 10% oxygen.

21. Emissions from Vent II must be less than 5 ppm on dry basis corrected to 10% oxygen, or proven to have negligible flow, or fitted with a check valve that will protect the tank without allowing emissions.

22. A continuous monitoring system to monitor and record the concentration of TRS emissions, oxygen content of calciner emissions, and scrubber pressure drop will be provided and certified in accordance with Title 40, Chapter 1, Subchapter C, Part 60, Subparts 60.284 and 60.285 as published by EPA in the Federal Register Vol. 43 No. 37, February 23, 1978. A copy of certification tests will be submitted to complete an application to operate (condition 16 above).

Expiration Date:

April 1, 1983

Issued this 10th day of October, 1979.

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL REGULATION

Robert V. Kriegel
District Manager

BEST AVAILABLE COPY

AIR PERMIT NO. AC 17-21829

DOCUMENTATION FOR SUPPORTING
AIR PERMIT FILE APPROVAL
(Reference: Memo P.J.D. to H.S., April 24, 1978 - Filed: Permitting)

I. Stationary Source Information (operating rate, new or existing, etc.)

A new Kamyr continuous digester, wash system, non-condensable gas system and Fluosolids (lime) calciner which will add 750 tons/day of air dried pulp to their papermaking capacity.

II. Source Emission Limiting Standards and Allowances (Regulation(s) and calculations for each pollutant)

BACT is applicable because PSD is applicable (6884 Tons/yr potential particulate and 260 Tons/yr potential SO_2).
NSPS is applicable.
BACT was determined (see attachment dated Sept 21 1979) as equal to NSPS.
TRS 8 ppm by volume at 10% oxygen.
particulates 0.067 grains/dry std. cu ft.
Continuous monitoring.
SO_2 not specified

III. Control Technology furnished by Source

All TRS sources (digester & wash system) are ducted to a condenser the non-condensable gases from this system are ducted to the calciner. The Total Reduced Sulfur is incinerated in the calciner to SO_2. The SO_2 is absorbed in the calciner and scrubber by the lime to an extremely low level such that SO_2 emissions will actually be only 0.4 Ton/yr. The particulates are controlled by a wet scrubber.

IV. Proof of Compliance Tests (amount of emissions and date)

TRS test, particulates test, certification of continuous monitors.

V. Inspections (date and comments) Ambient monitoring sites with respect to the plant sites were inspected. Preconstruction ambient monitoring was required by EPA.

VI <u>PSD review</u> Class II allowed increment increases are 19 micrograms/meter^3 and 37 ug/m^3 for annual mean and 25 hr maximum respectively for particulates. For SO_2 the allowed increment increases are 20, 91, and 512 ug/m^3 for annual, 25 hr, and 3 hr maximums respectively. Only the annual impact of .71 ug for particulates and .007 ug/m^3 for SO_2 are presented here to show this ~~is~~ not a significant source. A more detailed presentation combining the impact of the calciner with the forthcoming new bark boiler also models the 24 hr ~~maxima~~ (this application has not yet been received, but it is known that the combination of the calciner and the much larger emissions of the bark boiler will only use ~ 1/3 of the particulates increment). PSD notification to EPA was mailed Oct. 8, 1979. [illegible]

JACK PREECE Issue this construction permit with conditions established by BACT. The impact on class II PSD is not significant (below 1µg/m³ annual average). The full PSD increment is available and no impact on a non attainment area or a Class I area.

Jack Preece
Oct 9, 1979

THOMAS MOODY ~~Henry Sobala~~: Major new facility, required PSD review. Review shows that source has insignificant impact on ambient air, but BACT employed regardless. Dept made BACT limits equal to NSPS. Recommend issue permit with BACT limits and testing and continuous monitoring required.

Thomas W Moody 10/9/79
(Signature)

P. J. Doherty: ______________________________

Signature ______________________
P. J. Doherty
District Engineer

Robert V. Kriegel: ______________________________

Signature ______________________
Robert V. Kriegel
District Manager

BEST AVAILABLE COPY

State of Florida

DEPARTMENT OF ENVIRONMENTAL REGULATION

INTEROFFICE MEMORANDUM

And/Or To Other Than The Addressee	
To:	Loctn.:
To:	Loctn.:
To:	Loctn.:
From:	Date:

TO: Jacob D. Varn
Secretary

FROM: J. P. Subramani, Chief
Bureau of Air Quality Management

DATE: September 18, 1979

SUBJECT: BACT Determination - Calciner and Digester
St. Regis Paper Company, Pensacola Mill
Expansion, Cantonment, Escambia County

RECEIVED

SEP 20 1979

DEPT. OF
ENVIRONMENTAL REGULATION

Facility: The proposed expansion of the St. Regis Pensacola Kraft Paper Mill will permit production of an additional 750 tons per day of air dried pulp. A single continuous Kamyr digester having 750 tons/day capacity will be added and also a new calciner of 125 tons per day capacity. Total potential emissions resulting from the expansion are: 6,884 tons/year of particulate, 260 tons/year of SO_2 and 96 tons/year of TRS.

BACT Determination Requested by the Applicant:

	TRS	Particulate
Kamyr Continuous Digester and Washer System and the Non-Condensable Gas System:	Emissions ducted to the condensate stripper and new calciner except: Negligible Vent I = 0.009 lbs/hr. Negligible Vent II = 0.009 lbs/hr.	
Fluidized Bed Calciner:	8ppm corrected to 10% O2	0.067 gr/dscf

Date of Receipt of a Complete BACT Application:

July 12, 1979

Date of Publication in the Florida Administrative Weekly:

July 27, 1979

H6 - Rev 7/76

Date of Publication in a Newspaper of General Circulation:

July 16, 1979

Study Group Members:

Michael Harley, DER Bureau or Air Quality Management, Tallahassee;
Robert Kappelmann, Department of Health, Jacksonville;
John Ketteringham, DER St. Johns River Subdistrict, Jacksonville;
Jack Preece, DER Northwest District, Pensacola

Study Group Recommendations:

	Continuous Digester and Washer System and Non-Condensable System	Calciner	
	TRS	TRS	Particulate
Michael Harley	Control washer vent emissions with incineration.	8ppm corrected to 10% oxygen on a dry basis (NSPS)	0.067 gr/dscf corrected to 10% oxygen (NSPS)
Robert Kappelmann	Ducting all major exhaust points of non-condensable gases to calciner for incineration, except for 2 vents on washing tanks with emission limits of 2ppm measured as H_2S at 10% excess O_2.	5ppm expressed as H_2S Continuous monitoring	0.067 gr/dscf corrected to 10% oxygen on number 6 or natural gas fuel
John Ketteringham	NSPS	NSPS	
Jack Preece	As proposed by applicant		

Summary of EPA's New Source Performance Standards (NSPS) for Kraft Pulp Mills*:

Continuous Digester and Washer System:	TRS:	Incineration or 5ppm

*Complete EPA's NSPS for Kraft Pulp Mills is given in CFR 60.283. (Attached in Appendix C)

Lime Kiln	Particulate: 0.067 gr/dscf corrected to 10% oxygen when gaseous fuel is burned TRS: 8ppm by volume at 10% oxygen

BACT Determination by Florida Department of Environmental Regulation:

Emission Limitations

Source	TRS	Particulate
Kamyr continuous digester and washer system and non-condensable gas system	Vents I and II 5ppm volume at 10% oxygen	
Calciner	8ppm by volume at 10% oxygen	0.067 gr/dscf

Monitoring

Continuous monitoring system as approved by the Department to monitor and record concentrations of TRS emissions and oxygen concentrations in gases discharged from the calciner.

Test Methods

Particulate	Florida Department of Environmental Regulation Pulp and Paper particulate method for wet stack is required for particulate emission.

Justification of DER Determination:

The proposed standard essentially agrees with EPA's NSPS (revised Feb. 23, 1978) and represents the state of the art for paper mill emission controls. Available test data does not justify a more stringent standard, nor does the air quality impact of the source as shown by the applicant's modeling.

Details of the Analysis May be Obtained by Contacting:

Victoria Martinez, BACT Coordinator
Department of Environmental Regulation
Bureau of Air Quality Management
2600 Blair Stone Road
Twin Towers Office Building
Tallahassee, Florida 32301

Recommendation from: Bureau of Air Quality Management

by: JP Subramani
J. P. Subramani

Date: SEPTEMBER 19, 1979

Approved by: Jacob D. Varn
Jacob D. Varn

Date: 21 SEPTEMBER 1979

JPS:es

Attachments

APPLICATION PSD-FL-029

FINAL DETERMINATION

PSD-FL-0029
ST. REGIS PAPER
PENSACOLA

I. Applicant

St. Regis Paper Company
Gulf Life Tower
Jacksonville, Florida 32207

II. Location

The proposed modification is to an existing plant located off Highway 29 near the city of Cantonment in Escambia County, Florida. The UTM coordinates of the proposed facilities are 468.0 East and 3385.0 West; the latitude is 30°36'19" North and longitude 87°19'13" West.

III. Project Description

The applicant proposes to modify its Pensacola Kraft pulp and paper mill by adding sufficient processing equipment to produce 700 tons per day of unbleached Kraft papers. Total plant production will be increased to 1300 to 1400 tons per day of paper products. The modification will include construction of the following facilities:

1. Wood chip preparation and materials handling (120 tons/hr),
2. Digester/Washer system (750 tons/day),
3. Black liquor evaporator system,
4. Condensate stripper system,
5. Lime calciner/liquor preparation system (63.5 tons/day of lime produced),
6. Paper production machine, and
7. Paper finishing and shipping facilities.

The expanded paper production capacity will utilize existing recovery boilers and tall oil and turpentine processing equipment and storage tanks. Utilization of existing facilities will not exceed current State permit conditions.

IV. Source Impact Analysis

The proposed modification has the potential to emit greater than 100 tons per year of sulfur dioxide (SO_2) and particulate (TSP) as shown in Table I. Therefore, in accordance with the provisions of Federal Regulation 40 CFR Part 52.21 promulgated June 19, 1978, Prevention of Significant Deterioration (PSD) review is required for each of these pollutants.

BACT/LAER CLEARINGHOUSE REPORT

BEST AVAILABLE COPY

SOURCE TYPE/SIZE: KRAFT PULP AND PAPER MILL (700 TONS/DAY)

NAME/ADDRESS: ~~[illegible]~~ ST REGIS PAPER COMPANY, PENSACOLA FLOR[illegible]

DETERMINATION IS: CONDITIONAL/FINAL/PENDING; ISSUED on ______ (date), BASIS* of BACT[1]/LAER/B[illegible]
for NEW/MODIFIED SOURCE

BY EPA REGION IV (Agency) ; (Person) (Ph[illegible]

PERMIT PARAMETERS:

AFFECTED FACILITIES	THROUGHPUT CAPACITY (Weight Rate)	POLLUTANT(s) EMITTED	EMISSION LIMIT(s) and (basis for)**	CONTROL STRATEGY DESCRI[illegible] Equipment Type, Etc.
WOOD CHIP TRANSPORT	120 T/ ~~DAY~~ HR	TSP	0% OPACITY [1]	BELT CONVEYOR
DIGESTER/WASHER	750 T/DAY	TRS	5 PPM – (N)	VENT TO CONDENSATE STRIPPER
LIQUOR EVAPORATION	—	TRS	5 PPM – (N)	" " " "
CONDENSATE STRIPPER	—	TRS	5 PPM – (N)	INCINERATE IN LIME CALCINE[illegible]
LIME CALCINER (FLUIDIZED BED)	63.5 T/DAY (LIME PRODUCED)	TSP	8.5 lb/hr (N)	HIGH ENERGY SCRUBBER
		SO_2	0.1 lb/hr (SOURCE)	LIME ABSORPTION AND SCRUBBER

NOTES: 1 STATED BY SOURCE AS ACHIEVED IN EXISTING UNIT.

* Circle one. BACT[1] means a determination made under pre-1977 amendments; BACT[2] means post-1977 amendments to CAA.

** Basis symbols: Use B=BACT, N=NSPS, S=SIP, L=LAER

Compliance with the HC emission limit will be determined by calculation from the flow rate and the HC concentration with the HC concentration being measured by a flame ionization detector calibrated with propane to a sensitivity of less than one ppm. Sampling periods must be at least 60 minutes per run with three runs per test. Concentration measurements can be made directly from the stack or from integrated bag samples. The volumetric flow rate will be determined with EPA standard method 2.

V. Conclusions

EPA Region IV proposes a final determination of approval for construction of the modification to the St. Regis Paper Company paper plant proposed in their application submitted July 12, 1979. This approval is based on the information provided in their application and additional information submitted in correspondence dated August 22, 1979, and August 29, 1979. The conditions set forth in the permit are as follows:

1. The modification and the facilities constructed will be in accordance with the capacities and specifications stated in the application.

2. The facilities will comply with all applicable provisions of 40 CFR Part 60 Subpart BB, the NSPS for Kraft pulp mills. This includes but is not limited to the requirements outlined in Table II.

   Compliance with the requirements of the NSPS will be determined in accordance with the provisions of that regulation.

3. In addition to condition 2, the following allowable emission rates must be met:

Facility	Allowable Emission Rate
Lime Calciner	TSP - 8.5 pounds per hour
	SO_2 - 0.1 pounds per hour
	NO_2 - 15.3 pounds per hour (NO_x as NO_2)
	HC - 10.5 pounds per hour
Woodchip preparation and transport facilities	TSP - ZERO percent opacity as measured by EPA standard method 9

4. Compliance with allowable emission rates specified in condition 3 will be determined by performance tests within 90 days of startup and the test results will be reported to EPA Region IV within 120 days of test completion. Performance tests will be in accordance with the provisions of 40 CFR 60.8 and as such will use appropriate EPA standard methods as outlined in 40 CFR 60 Appendix A. The process will operate within 10 percent of maximum capacity during source sampling. Further, the minimum sampling times and rates are as follows for the lime calciner:

Pollutant	Test Method	Minimum Sampling Requirements
TSP	Method 5	60 min/run; 0.53 dscf/run
SO_2	Method 6	20 min/sample; 0.71 dscf/sample; 2 samples per run (arithmetic mean) at about 30 min. intervals
NO_2	Method 7	4 grap samples per run at about 15 min. intervals (arithmetic mean).

TABLE II

NSPS REQUIREMENTS
SUMMARY

FACILITY	REQUIREMENTS	PROPOSED CONTROL STRATEGY
Digester/Washer System	TRS - 5 ppmv[a] Continuous Monitoring[b]	Vent to condensate stripper
Black Liquor Evaporation System	TRS - 5 ppmv[a]	Vent to condensate stripper
Condensate Stripper System	TRS - 5 ppmv[a] Continuous Monitoring[c]	Noncondensibles are incinerated in the lime calciner
Lime Calciner	TSP - 0.067 gr/dscf[d] at 10% O_2 TRS - 8 ppmv at 10% O_2 Continuous Monitoring[e]	High energy scrubber

a. No gases with greater than 5 ppm TRS measured on a dry basis at 10% O_2 will be discharged to the atmosphere.

b. Vents I and II will require continuous monitoring of TRS and O_2; other vents are exempt because the gases are ultimately incinerated in the lime calciner.

c. Incineration temperature in the calciner must be monitored continuously.

d. Note, the applicant stated that this rate would be met for both gas and oil firing even though the NSPS includes a 0.13 gr/dscf limit for oil firing.

e. The pressure drop in the gas stream across the scrubber and the scrubbing liquid supply pressure must be monitored consistent with NSPS requirements.

Full PSD review includes analyses of Best Available Control Technology (BACT), Class I area impact, National Ambient Air Quality Standards (NAAQS) impact, increment impact, growth impact, and additional impacts on soils, vegetation and visibility. However, because allowable emissions of these pollutants are less than 50 tons per year, as shown in Table I, and no class I area is impacted, the modification is exempt from these impact analyses consistent with paragraph (k) of the PSD regulation. On this same basis, the source is exempt from the monitoring requirements of paragraph (n) of the PSD regulation. PSD review for this modification is limited to a Class I area impact analysis and ensuring that the applicable facilities meet emission limitations under the Florida State Implementation Plan and Standards of Performance under 40 CFR Part 60 and Part 61.

It should be noted that the county in which the source is located is classified as "attainment" with respect to the NAAQS for TSP, NO_x, and CO, but the county is unclassified for SO_2 and photochemical oxidants. This fact, however, does not affect the PSD review because detailed air quality review and ambient monitoring are not required for this modification as was discussed previously.

CONTROL TECHNOLOGY

Even though this modification is exempt from BACT analysis, the source is a Kraft pulp mill and the new emitting facilities are therefore subject to the New Source Performance Standard (NSPS) 40 CFR Part 60 Subpart BB. As is stated in the conclusions section all applicable facilities are required to meet the emission standards and standards of performance specified in the regulation. For the facilities in this modification, the requirements and proposed control strategies are summarized in Table II. This table only summarizes the major requirements. The NSPS contains additional record keeping, reporting and other requirements with which the source will have to comply.

The emission limits in the Florida State Implementation Plan for black liquor recovery furnaces do not apply to this modification because no additional recovery boilers are to be constructed. The process weight rate TSP emission limit will be met by the proposed allowable emission rates.

CLASS I AREA IMPACT

The applicant modeled air quality impacts from the proposed modification using standard EPA model AQDM, ten year meteorological data, and maximum emission rates. The analysis showed maximum ground level concentrations to be less than the significance levels outlined in the preamble to the PSD regulation. These maximum concentrations occur at a distance of one kilometer from the source. Since the closest Class I area, Breton National Wildlife Refuge, is over 100 kilometers from the source, it is concluded that the proposed modification will have no impact on a Class I area.

TABLE I

EMISSIONS SUMMARY

	SO_2	NO_2	TSP	CO	HC	TRS
Potential Emissions[a] (tons per year)	260	67	6884	<1	46[b]	96
Emissions After Controls (tons per year)	0.4	67	37	<1	46[b]	0.16[c]
Allowable Emissions [d]	0.4	e	37	e	e	e

a. As calculated by the applicant using maximum rated capacities.

b. The applicant reestimated HC emissions to be 22 tons per year. If supporting data is obtained, the lesser value can be used for accumulating emissions in reviews of subsequent modifications to this source.

c. Emitted as SO_2 following incineration in calciner.

d. Stated in the application as maximum actual emissions assuming continuous operation.

e. Potential emissions of these pollutants are less than 100 per year, therefore PSD review does not apply.

Smallwood, S.

JAN 3 1980

RECEIVED JAN 7 1980 DEPT. OF ENVIRONMENTAL REGULATION BUREAU OF AIR QUALITY MANAGEMENT

Ref: 4AH-AF

Mr. Donald Ferguson
Environmental Engineer
St. Regis Paper Company
Gulf Life Tower
Jacksonville, Florida 32207

Re: EPA PSD-FL-029

Dear Mr. Ferguson:

In response to our conversation and your letter of October 17, 1979, EPA has noted the discrepancy between your application (PSD-FL-029) and your permit regarding the production capacity of your lime calciner/liquor preparation system. It is understood and recorded in our files that the production capacity is 125 tons per day rather than 63.5 tons per day as written in the final determination.

No further change is required in the permit as issued. As stated in Condition 1 of the permit, the capacity of the calciner is set by the quantity specified in your application (125 tons per day).

We appreciate being of service in this regard.

Sincerely yours,

Tommie A. Gibbs
Chief
Air Facilities Branch

cc: Florida, DER

Sobronni

OCT 11 1979

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

REF: 4AH-AF

Mr. D. Ferguson
St. Regis Paper Company
Gulf Life Tower
Jacksonville, Florida 32207

Dear Mr. Ferguson:

Review of your July 15, 1979 application to construct additional process equipment at the kraft pulp mill near Cantonment, Florida has been completed. The construction is subject to rules for the Prevention of Significant Air Quality Deterioration (PSD), contained in 40 CFR 52.21.

We have determined that the construction, as described in the application, meets all applicable requirements of the PSD regulations, subject to the conditions in the Final Determination (enclosed). The Environmental Protection Agency performed the Preliminary Determination concerning the proposed construction, and published a request for public comment on September 7, 1979 . No comments were received. Authority to Construct a Stationary Source is hereby issued for the facility described above, subject to the conditions in the State permit. This Authority to Construct is based solely on the requirements of 40 CFR 52.21, the federal regulations governing significant deterioration of air quality. It does not apply to NPDES or other permits issued by this agency or permits issued by other agencies. Information regarding EPA permitting requirements can be provided if you contact Mr. Joe Franzmathes, Director, Office of Program Integration and Operations, at 404/881-3476. Additionally, construction covered by this Authority to Construct must be initiated within 18 months from the receipt of this letter.

The United States Court of Appeals for the D. C. Circuit has issued a ruling in the case of Alabama Power Co. vs. Douglas M. Costle (78-1006 and consolidated cases) which has significant impact on the EPA prevention of significant deterioration (PSD) program and permits issued thereunder. Although the court has stayed its decision pending resolution of petitions for reconsideration, it is possible that the final decision will require modification of the PSD regulations and could affect permits issued under the existing program. Examples of potential impact areas include the scope of best available control technology (BACT), source applicability, the amount of increment available (baseline definition), and the extent of preconstruction monitoring that a source may be required to perform. You are hereby advised that this permit may be subject to reevaluation as a result of the final court decision and its ultimate effect.

Please be advised that a violation of any condition issued as part of this approval, as well as any construction which proceeds in material variance with information submitted in your application will be subject to enforcement action.

Authority to Construct will take effect on the date of this letter. The complete analysis which justifies this approval has been fully documented for future reference, if necessary. Any questions concerning this approval may be directed to Tommie A. Gibbs, Acting Chief, New Source Review Section (404/881-4552).

Sincerely yours,

Thomas W. Devine
Director
Air and Hazardous Materials Division

Enclosure

cc: FL Department of Environmental Regulation

4AH-AE:Brandon:gray:2786:10/11/79

ST. REGIS PAPER CO.
AIR PERMIT APPLICATIONS

Pensacola Mill Expansion

JULY 1979

submitted by:

St. Regis Paper Company
Gulf Life Tower
Jacksonville, Florida 33207

ST. REGIS PAPER CO.

AIR PERMIT APPLICATIONS

PENSACOLA MILL EXPANSION

Submitted By

St. Regis Paper Company
Gulf Life Tower
Jacksonville, Florida 33207

July 12, 1979

ST REGIS PAPER COMPANY Gulf Life Tower, Jacksonville, Florida 32207 (904) 396-5741

July 12, 1979

Mr. Robert Kriegel, District Manager
Department of Environmental Regulation
160 Governmental Center
Pensacola, Florida 32501

Subject: St. Regis Paper Company - Pensacola
Application to Construct
Paper Mill Expansion

Dear Mr. Kriegel:

I am enclosing with this letter the Applications for Best Available Control Technology (BACT), Prevent Significant Deterioration (PSD) and Permit to Construct for the Air Emission Sources for the Pensacola Paper Mill Expansion. A check for the twenty dollar filing fee is attached.

At a later date, we will submit a set of applications for the Bark Boiler portion of the expansion.

We are submitting a set of these same applications to the EPA, Region IV, in Atlanta for their review.

Should you have any questions about the information presented, please call me at (904)396-5741 or call Mr. M. E. Lukey of Engineering Science at (703) 790-9300.

Very truly yours,

D. M. Ferguson
Environmental Engineer

DMF/abl

cc: Mr. Roger Pfaff
EPA Region IV
345 Courtland Street
Atlanta, Georgia 30308

ST REGIS PAPER COMPANY Gulf Life Tower, Jacksonville, Florida 32207 (904) 396-5741

July 12, 1979

Mr. Roger Pfaff
EPA Region IV
345 Courtland Street
Atlanta, Georgia 30308

Subject: St. Regis Paper Company - Pensacola
Applications for BACT
Paper Mill Expansion

Dear Mr. Pfaff:

I am enclosing with this letter applications for Best Available Control Technology (BACT) for the Air Emission Sources for the Pensacola Paper Mill Expansion. In agreement with your conversations with Mike Lukey of Engineering Science, we are using the State of Florida BACT forms.

At a later date, we will submit an application for the Bark Boiler portion of the expansion.

We are at this time submitting these applications to the State of Florida Department of Environmental Regulation for their review.

Should you have any questions about the information presented, please call me at (904) 396-5741 or call Mike Lukey of Engineering Science at (703)790-9300.

Very truly yours,

D M Ferguson

D. M. Ferguson
Environmental Engineer

DMF/abl

cc: Mr. Robert Kriegel
Florida DER - Pensacola

TABLE OF CONTENTS

APPLICATION FOR THE DETERMINATION OF
BEST AVAILABLE CONTROL TECHNOLOGY FOR THE ST. REGIS
PAPER MILL EXPANSION IN PENSACOLA FLORIDA

July 1979

The Florida Department of Environmental Regulations (DER) has adopted rules governing the control of air pollution emanating from new sources locating in the state.

The St. Regis Paper Company is seeking approval and permits to add 750 tons per day of air dried pulp capacity to its Pensacola Mill located in Cantonment, Escambia County in western Florida. St. Regis has engaged the firm of Ford, Bacon and Davis to complete a preliminary design of the plant. As a result of that effort, several potential sources of air pollution were identified and methods to reduce these emissions below required levels were also analyzed. Engineering-Science (ES), consultants to St. Regis on environmental problems, also assisted in reviewing DER and U.S. Environmental Protection Agency (EPA) permitting requirements for the mill expansion.

This package contains the application forms for determining best available control technology (BACT) and the prevention of significant deterioration (PSD) review and application to construct. The two sources which are covered are listed below:

- o fluidized bed calciner;
- o Kamyr® continuous digester and washer system; and the non-condensable gas system (multiple effects evaporation system, digester system and condensate strippers).

These listed sources are the only sources of air pollution anticipated for the pulp and paper mill expansion. Application forms for a planned bark-boiler will be submitted to DER separately.

The selection of the best system for controlling emissions was based on the following criteria:

1. All Florida and EPA regulations where specific mass emission limits or exit concentrations were defined had to be met.
2. The system would have to be reliable (i.e., that system which would have the least down time).
3. The system would represent the best technology for reducing emissions to acceptable levels.
4. The system would have to be safe in terms of potential for fire, explosion and personnel hazards.

There were other factors considered in evaluating the control systems. Of particular importance was the type of equipment which is used to control emissions at the existing sources in the mill. The knowledge and experience that St. Regis personnel have in operating air pollution abatement systems is paramount when considering the selection of control devices. The capital cost and annual operating and maintenance costs were also considered.

AIR POLLUTION EMISSIONS (BACT AND PSD CONSIDERATIONS)

Ford, Bacon and Davis developed specific information on emissions, required removal efficiency, basic design parameters for the control devices (e.g., inlet loading, temperature, gas flow rate) and detailed cost estimates for the control device which was selected. ES used this data to estimate the performance and cost for the control systems, as required on the BACT application form. In making this analysis ES used EPA publications[†] and recent articles which appeared in the Journal of the Air Pollution Control Association.[††] (Please see Attachments B, C, and D for further information on BACT selection).

† Capital and Operating Costs of Selected Air Pollution Control Systems, U.S. EPA Publication EPA 450/3-76-014, U.S. EPA, May 1976.

†† Neveril, R.B., et al, Capital and Operating Costs of Selected Air Pollution Control Systems, JAPCA Vol. 28, Nos. 8 through 12, August to December 1978.

Table I is a summary of the emissions from the proposed new sources at the Pensacola Mill. Also shown in the table are the levels of control achieved for each of the alternate systems considered in this analysis.

In summary, St. Regis is proposing to use the best available control technology to reduce emissions to acceptable levels at the Pensacola Mill. The resultant control system proposed and their emissions are summarized below:

- fluidized bed calciner (venturi scrubber) - 37 tpy of TSP
- noncondensable gas system (incineration in calciner) - 0.4 tpy of SO_2
- Kamyr washer system (included in noncondensable system) - <1 tpy of TRS

The vents from the two tanks on the Kamyr washer are open to the atmosphere. However, because the liquid levels in the tanks do not fluctuate rapidly, we do not foresee a significant amount of emissions from these sources (less than 0.08 tpy of TRS). The air quality impact from these sources was estimated by modeling and found to be less than 1 $\mu g/m^3$ on an annual basis. Thus a detailed air quality analysis was not required by the Florida DER. Since the post controlled emissions are less than 50 tpy, a detailed air quality analysis is not required by EPA.

The BACT/PSD/Construction Application follows.

TABLE I

SUMMARY OF AIR POLLUTION EMISSIONS FROM NEW SOURCES AT THE ST. REGIS PENSACOLA MILL

	EMISSIONS (tons per year)				
SOURCE/POLLUTANT	UNCONTROLLED	VENTURI SCRUBBER	ELECTROSTATIC PRECIPITATOR	BAG-HOUSE	INCINERATION
Fluidized Bed Calciner					
TSP	e	37	NA	NA	NA
SO_2[a]	e	.4	NA	NA	NA
HC	46[f]	46			
NO_x	67[f]	67			
CO	<1[f]	<1			
Kamyr Washer System					
TRS	<.08	NA	NA	NA	(.16)[b]
Non Condensable Gas System					
TRS	4[d]	NA	NA	NA	c

NA - not applicable

a - fuel oil; sulfur content is 2.5%.

b - When burned the TRS will convert to SO_2. The value is for SO_2 emissions.

c - Incinerated in calciner.

d - emission based on stack tests at the Pensacola Mill lime kiln dated June 28, 1978.

e - The venturi scrubber is part of the Fluo Solids Calciner System. As an integral part of the process the scrubber provides process hot water and is used to recover chemicals such as sodium for reuse in the process. Furthermore, it is effective in reducing TSP and SO_2 emissions to the atmosphere.

f - There was no published data on calciner emissions for these pollutants. These estimates are for a lime kiln of similar capacity and may not accurately reflect emissions for these pollutants. Other factors such as fuel efficiency and combustion zone temperature will affect the emissions of these contaminates. It should be noted that the calciner will use less energy than a conventional lime kiln.

AC17-21829

BEST AVAILABLE COPY

(16)

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

PAID
JUL 12 1979
20.00
Km

APPLICATION TO OPERATE/CONSTRUCT
AIR POLLUTION SOURCES

SOURCE TYPE: ____________ (X) New[1] ( ) Existing[1]

APPLICATION TYPE: (X) Construction ( ) Operation ( ) Modification

COMPANY NAME: St. Regis Paper Company COUNTY: Escambia

Identify the specific emission point source(s) addressed in this application (i.e. Lime Kiln No. 4 with Venturi Scrubber; Peeking Unit No. 2, Gas Fired) Flue-Solids Unit #1

SOURCE LOCATION: Street Highway 29 City Cantonment

UTM: East 468 North 3385

Latitude 30 ° 36 ' 19 "N Longitude 87 ° 19 ' 13 "W

APPLICANT NAME AND TITLE R. T. Hudson, Resident Manager

APPLICANT ADDRESS St. Regis Paper Co., Kraft Center, Pensacola, P. O. Box 87, Muscogee Road, Cantonment, Fla. 32833

SECTION I: STATEMENTS BY APPLICANT AND ENGINEER

A. APPLICANT

I am the undersigned owner or authorized representative* of St. Regis Paper Company

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.

Signed: [signature]

R. T. Hudson, Resident Manager
Name and Title (Please Type)

*Attach letter of authorization

Date: 7-12-79 Telephone No. 904-968-2121

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 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: [signature]

Andrew W. Loven, Ph.D.
Name (Please Type)

(Affix Seal)

A. W. LOVEN
CERTIFICATE
No. 21813
STATE OF
FLORIDA
REGISTERED ENGINEER

Engineering-Science, Inc.
Company Name (Please Type)

57 Executive Park South, N.E.
Atlanta, Georgia 30329
Mailing Address (Please Type)

Florida Registration No. 21813 Date: 7-11-79 Telephone No. 404/325-0770

[1]See Section 17-2.02(15) and (22), Florida Administrative Code, (F.A.C.)

DER Form 17-1.122(16)

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

All state and federal environmental requirements will be met.

B. Schedule of project covered in this application (Construction Permit Application Only)

Start of Construction Sept. 1, 1979 Completion of Construction 1982

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.)

The venturi scrubber is part of the fluidized bed calciner system.

The system total cost is $3,500,000 installed.

The scrubber will cost about $75,000.

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

None

E. Is this application associated with or part of a Development of Regional Impact (DRI) pursuant to Chapter 380, Florida Statutes, and Chapter 22F-2, Florida Administrative Code? ___ Yes X No

F. Normal equipment operating time: hrs/day 24; days/wk 7; wks/yr 51; if power plant, hrs/yr ______; if seasonal, describe:

NA

G. If this is a new source or major modification, answer the following questions. (Yes or No)

1. Is this source in a non-attainment area for a particular pollutant? No
   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. Yes
3. Does the State "Prevention of Significant Deterioriation" (PSD) requirements apply to this source? If yes, see Sections VI & VII. Yes
4. Do "Standards of Performance for New Stationary Sources" (NSPS) apply to this source? Yes
5. Do "National Emission Standards for Hazardous Air Pollutants" (NESHAP) apply to this source? No

Attach all supportive information related to any answer of "Yes". Attach any justification 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 Type	Contaminants % Wt	Utilization Rate - lbs/hr	Relate to Flow Diagram
Wood (chips)			240,000	See Attachment A
Cooking liquor			216,000	See Attachment A

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

1. Total Process Input Rate (lbs/hr): 456,000 chips and liquor; lime mud = 20574 lb/hr
2. Product Weight (lbs/hr): 62,500 air dried pulp 10417 lbs/hr lime

C. Airborne Contaminants Emitted: (Total for mill expansion)

Name of Contaminant	Emission[1] Maximum lbs/hr	Emission[1] Actual T/yr	Allowed Emission[2] Rate per Ch. 17-2, F.A.C.	Allowable[3] Emission lbs/hr	Potential[4] Emission lbs/hr	Potential[4] Emission T/yr	Relate to Flow Diagram
TSP	8.4	37	15.23 lb/hr[d]	11.41[a]	1607	6884	Att D
SO_2	.09	.4	NA	NA	60.6[c]	260	"
TRS	.9	4	NA	BACT/NSPS	22.5[b]	96	"

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

Name and Type (Model & Serial No.)	Contaminant	Efficiency %	Range of Particles[5] Size Collected (in microns)	Basis for Efficiency (Sec.V,It5)
Venturi scrubber	TSP	99+	>1	Calculation
Calciner/scrubber	SO_2	~90	NA	based on manufacturer
Calciner	TRS	99+	NA	guarantee

[1] See Section V, Item 2.
[2] Reference applicable emission standards and units (e.g., Section 17-2.05(6) Table II, E.(1), F.A.C. -- 0.1 pounds per million BTU heat input)
[3] Calculated from operating rate and applicable standard
[4] Emission, if source operated without control (See Section V, Item 3)
[5] If Applicable

[a] This is slightly less than 50 tpy

[b] Without incineration and scrubbing

[c] With oxidation of H_2S and S in fuel and no removal by lime or scrubber.

[d] Based on a process weight of 20,574 lb/hr of lime mud.

E. Fuels in calciner

Type (Be Specific)	Consumption* avg/hr	max./hr	Maximum Heat Input (MMBTU/hr)
Natural gas [a]	.039		41
Oil [a] (#6)[a]	6.52		41

*Units Natural Gas,MMCF/hr; Fuel Oils, barrels/hr; Coal, lbs/hr

Fuel Analysis: (#6 oil)

Percent Sulfur: 2.5 Percent Ash: 0.10

Density: ______ lbs/gal Typical Percent Nitrogen: ______

Heat Capacity: ______ BTU/lb 145,000 BTU/gal

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

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

Annual Average None Maximum ______

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

None - closed cycle system

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

Stack Height: 88 ft. Stack Diameter: 3 ft.

Gas Flow Rate: 15,500 dscfm Gas Exit Temperature: 160 °F.

Water Vapor Content 29 % Velocity: 35 FPS

[a] Data shown assuming one fuel used (i.e. all gas or all oil)

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.)
Lbs/hr Incinerated							

Description of Waste ____________________

Total Weight Incinerated (lbs/hr) __________ Design Capacity (lbs/hr) ___

Approximate Number of Hours of Operation per day _______ days/week _______

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* Velosity __________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.):

SECTION V: SUPPLEMENTAL REQUIREMENTS

Please provide the following supplements where required for this application.

1. Total process input rate and product weight - show derivation. (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 next page)

3. Attach basis of potential discharge (e.g., emission factor, that is, AP42 test). (See next page)

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, etc.). (See next page)

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 next page)

6. An 8½" 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, B, C and D).

7. An 8½" 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). (See Attachment F)

8. An 8½" x 11" plot plan of facility showing the location of manufacturing processes and outlets for airborne emissions. Relate all flows to the flow diagram. (See Attachment F)

9. An application fee of $20, unless exempted by Section 17-4.05(3), F.A.C. The check should be made payable to the Department of Environmental Regulation. (enclosed)

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. (Not Applicable)

SECTION V

SUPPLEMENTAL REQUIREMENTS

#2 BASIS OF EMISSION ESTIMATES

The estimates of TSP and SO_2 emission from the fluidized bed calciner were obtained from Dorr Oliver who have guaranteed (Attachment D) that the particulate emissions will meet federal and state emission regulations. In addition to this guarantee, there are several published articles on the operating experience of the fluidized bed calciner which confirm that its scrubbers can achieve a grain loading of less than 0.067 gr/dscf, even when firing with oil. (See Attachments D and E.) We are submitting a copy of the guarantee and the published data as proof that the calciner will meet Florida and EPA standards.

#3 BASIS OF POTENTIAL DISCHARGE

According to EPA[1] potential (uncontrolled) particulate emissions can range from 3 to 15 gr/dscf. Assuming that the flow rate for a 125 tpd calciner is about 12,500 scfm, the potential emission rate will range from 1,400 to 7,000 tpy. However, since the scrubber is vital to production of the normal product of the mill, this calciner could not be operated if the scrubber malfunctioned. Thus the potential emissions represent theoretical estimates of the emissions if the calciner could operate without the scrubber.

Estimates of TRS emissions from the evaporators were based on EPA's AP-42 and NCASI factors for the multiple effects evaporators and the washer system. The TRS emissions will be incinerated in the calciner.

---

[1] Environmental Pollution Control, Pulp and Paper Industry, Part I - Air, U.S. EPA, October 1976, EPA-625-7-76-001.

#4 DESIGN DETAILS FOR AIR POLLUTION CONTROL SYSTEMS

A high energy venturi scrubber will be used as part of the fluidized bed calciner system.

The venturi scrubber will have a variable throat capable of keeping the pressure drop constant at 20" of H_2O. The inlet flow rate will be 24,893 acfm at 325°F. The water recirculation rate will be approximatley 300 gpm. The calciner process is so effective in removing SO_2 that the scrubber will be made of carbon steel. No mist eliminator will be used.

#5 DERIVATION OF CONTROL EFFICIENCY

The following assumptions were used to calculate the required control efficiency of the scrubber:

Inlet grain loading, maximum	15 gr/dscf
Outlet grain loading requirement	0.067 gr/dscf[a]

Control efficiency $\frac{15.000 - .067}{15.000} \times 100 = 99.5\%$

By meeting this grain loading requirement, TSP emissions will meet Federal and State emission regulations. In addition the TSP emissions will be less than 40 tons per year.

[a] The outlet grain loading was determined by (1) considering the level necessary to achieve the NSPS, (2) the manufacturer's guarantee, and (3) test data from similar calciner operations.

SECTION VI: BEST AVAILABLE CONTROL TECHNOLOGY

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

(x) Yes ( ) No

Contaminant	Rate or Concentration
TRS	Incineration or <5 ppm
	(CFR 60.283)

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

( ) Yes (x) No

Contaminant	Rate or Concentration

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

Contaminant	Rate or Concentration
TRS (0.62 lb/hr)	Almost all of the emissions are sealed
(AP-42)	and sent to condensate stripper and new calciner.
	Negligible Vent I = .009 lb/hr Negligible Vent II = .009 lb/hr

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

1. Control Device/System: Maintain liquid level in vented tanks as constant as possible.
2. Operating Principles: Relief gas from steaming vessel, digester and flash tanks goes to condensate stripper
3. Efficiency:*
4. Capital Costs:
5. Useful Life:
6. Operating Costs:
7. Energy:
8. Maintenance Cost:
9. Emissions:

Contaminant	Rate or Concentration
TRS	1-2 ppm** < .04 tpy TRS

*Explain method of determining D 3 above.

** These fugitive emissions will result from fluctuations in the liquid of two washer tanks which are vented to the atmosphere.

10. Stack Parameters not applicable

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 neceaasry).

1.

a. Control Device: Incineration in new calciner.

b. Operating Principles: Off gas from condensate stripper goes to non-cond. gas system for incineration.

c. Efficiency*: 99% d. Capital Cost:

e. Useful Life: life of calciner f. Operating Cost:

g. Energy*: included with calciner h. Maintenance Cost:

(d., f., h.: included in cost of calciner)

i. Availability of construction materials and process chemicals: available

j. Applicability to manufacturing processes:

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

2. Separately fired incinerator

a. Control Device: S~~eparately fired~~ incinerator

b. Operating Principles: Off gas from condensate stripper are incinerated

c. Efficiency*: 99% d. Capital Cost: $33,000[a]

e. Useful Life: 20 years f. Operating Cost:

g. Energy**: NA h. Maintenance Costs:

(f., h.: $61,000/yr)

i. Availability of construction materials and process chemicals·

Material for construction are available

j. Applicability to manufacturing processes:

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

*Explain method of determining efficiency.
**Energy to be reported in units of electrical power - KWH design rate.

[a] Based on a 20,000 acfm unit with a temperature of at least 1200°F and a retention time of 0.5 seconds.

KAMYR CONTINUOUS DIGESTER AND WASHING SYSTEM AND THE NON-CONDENSABLE GAS SYSTEM

3. NA

a. Control Device:

b. Operating Principles:

c. Efficiency*:

d. Capital Cost:

e. Life:

f. Operating Cost:

g. Energy:

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. NA

a. Control Device

b. Operating Principles:

c. Efficiency*:

d. Capital Cost:

e. Life:

f. Operating Cost:

g. Energy:

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: Non Condensible gas system/ incineration

1. Control Device:

2. Efficiency*:

3. Capital Cost:

4. Life:

5. Operating Cost: } included with calciner

6. Energy:

7. Maintenance Cost: } included with calciner

8. Manufacturer:

9. Other locations where employed on similar processes:

a. NA

(1) Company:

(2) Mailing Address:

(3) City:

(4) State:

(5) Environmental Manager:

(6) Telephone No.

*Explain method of determining efficiency above.

DER FORM 17-1.122(16)

(7) **Emissions:***

CONTAMINANT	RATE OR CONCENTRATION

(8) **Process Rate:***

b. NA

(1) **Company:**

(2) **Mailing Address:**

(3) **City:** (4) **State:**

(5) **Environmental Manager:**

(6) **Telephone No:**

(7) **Emissions:***

CONTAMINANT	RATE OR CONCENTRATION

(8) **Process Rate:***

10. **Reason for selection and description of systems:**

Compared to other washer systems the Kamyr System will result in the least TRS or SO_2 being emitted to the atmosphere. All main vents and holding tanks are connected to the non-condensable gas system. This gas stream will be incinerated in the fluidized bed calciner.
A separately fired incinerator would mean additional capital costs and operating costs with no improvement in control. Therefore, the calciner will be used to incinerate the gases.

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

SECTION VI: BEST AVAILABLE CONTROL TECHNOLOGY

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

(x) Yes ( ) No

Contaminant	Rate or Concentration
TSP	.067 gr/dscf gas fired
	.130 gr/dscf oil fired
TRS	<8 ppm corrected to 10% O_2
SO_2	No Standard

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

( ) Yes (x) No

Contaminant	Rate or Concentration

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

Contaminant	Rate or Concentration
TSP	0.067 gr/dscf
TRS	<8 ppm corrected to 10% O_2

D. Describe the existing control and treatment technology (if any). N/A

1. Control Device/System:
2. Operating Principles:
3. Efficiency:*
4. Capital Costs:
5. Useful Life:
6. Operating Costs:
7. Energy:
8. Maintenance Cost:
9. Emissions:

Contaminant	Rate or Concentration

*Explain method of determining D 3 above.

10. Stack Parameters

a. Height: ft. b. Diameter: ft.

c. Flow Rate: SCFM d. Temperature: °F

e. Velocity: FPS

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

1. Calciner/scrubber

a. Control Device:

b. Operating Principles: The venturi scrubber is an integral part of the Fluo Solids Calciner System. It is used to provide process hot water and to recover valuable chemicals which are reused in the process. Neither baghouses or precipitators could meet the process needs. The scrubber is also effective in reducing TSP and SO_2 emissions in the atmosphere.

c. Efficiency*: d. Capital Cost:

e. Useful Life: f. Operating Cost: (included with process equipment)

g. Energy*: 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. NA [a]

a. Control Device:

b. Operating Principles:

c. Efficiency*: d. Capital Cost:

e. Useful Life: f. Operating Cost:

g. Energy**: h. Maintenance Costs:

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:

*Explain method of determining efficiency.
**Energy to be reported in units of electrical power - KWH design rate.

[a] There are no other air pollution control devices which have been used in conjunction with the Dorr Oliver Calciner unit.

3. NA

a. Control Device:

b. Operating Principles:

c. Efficiency*: d. Capital Cost:

e. Life: f. Operating Cost:

g. Energy: 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. NA

a. Control Device

b. Operating Principles:

c. Efficiency*: d. Capital Cost:

e. Life: f. Operating Cost:

g. Energy: 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: None other than the venturi scrubber.

2. Efficiency*: 3. Capital Cost:

4. Life: 5. Operating Cost:

6. Energy: 7. Maintenance Cost:

8. Manufacturer:

9. Other locations where employed on similar processes:

a.

(1) Company: P. H. Glatfelter Co.

(2) Mailing Address:

(3) City: Spring Grove (4) State: PA 17362

(5) Environmental Manager: Lee Bingham

(6) Telephone No. 717/225-4711

*Explain method of determining efficiency above.

(7) **Emissions:***

CONTAMINANT	RATE OR CONCENTRATION
TSP	0.069 gr/dscf 39 tpy (See Attachment D)

(8) **Process Rate:*** 136 tons/day lime produced

b.

(1) **Company:** S. D. Warren

(2) **Mailing Address:** 2400 Lake Shore Drive

(3) **City:** Muskegon (4) **State:** Michigan 49443

(5) **Environmental Manager:** Carl Kirkpatrick

(6) **Telephone No:** (616) 755-3761

(7) **Emissions:***

CONTAMINANT	RATE OR CONCENTRATION
TSP	0.010 gr/dscf (oil-fired)[a] (See Attachment E)

(8) **Process Rate:*** 63.5 tons/day lime produced

10. **Reason for selection and description of systems:**

The venturi scrubber is an integral part of the Dorr-Oliver Fluo Solids calciner. It will meet the NSPS standard for lime kilns and it meets Florida process weight limitations. Furthermore, St. Regis personnel have a great deal of experience in operating scrubbers at their Pensacola Mill. In the long run, this experience will minimize equipment malfunctions and downtime. The scrubber system will also minimize the SO_2 emitted from this process while fuel oil is used.

[a] This test was conducted using a dry thimble and may not have collected all of the particulate from the process.

*Applicant 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

A. Company Monitored Data N/A

1. ______no sites ______TSP ___( )SO_2* ______Wind spd/dir

Period of monitoring ___/___/___ (month day year) to ___/___/___ (month day year)

Other data recorded ______________________________

Attach all data or statistical summaries to this application.

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 See below

1. 10 Year(s) of data from 01 / 01 / 62 (month day year) to 12 / 31 / 71 (month day year)

2. Surface data obtained from (location) Whiting Field

3. Upper air (mixing height) data obtained from (location) Holzworth, EPA 1971

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

C. Computer Models Used See Attachment H

1. AQDM Modified? (Not 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 See Attachment H

Pollutant	Emission Rate
TSP	1.44 grams/sec
SO_2	.05 grams/sec

E. Emission Data Used in Modeling See Attachment H

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.
The predicted maximum groundlevel concentration of TSP was .710 $\mu g/m^3$, on an annual basis. The SO_2 predicted level was .007 $\mu g/m^3$. Attachment H contains the model results.

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

DER Form 17-1.122(16)

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.

SEE ATTACHMENT G

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.

SEE ATTACHMENT E

ATTACHMENT A

DESCRIPTION OF PAPER MILL EXPANSION

This expansion project will provide the necessary pulping, paper making and other facilities needed to produce 700 tons per day of additional unbleached kraft papers. (See flow sheet, Figure I.)

Major Features

Raw material Handling - Wood

Facilities will be added to handle 850 cords per day of wood received in logs, or chips. Logs will be barked and chipped and then the chips screened and stored in new or existing silos or outside chip storage and then conveyed to the digesters.

Processing - Pulp Mill

A single continuous Kamyr Digester of 750 tons/day capacity will be added to the existing pulp mill. Additional pulp produced will be up to 750 tons per day of pine pulp of either hard or soft quality as required.

Pulp will be washed, in a Kamyr Two Stage Diffusion Washer, screened, deckered and pumped to new storage tanks.

By Products

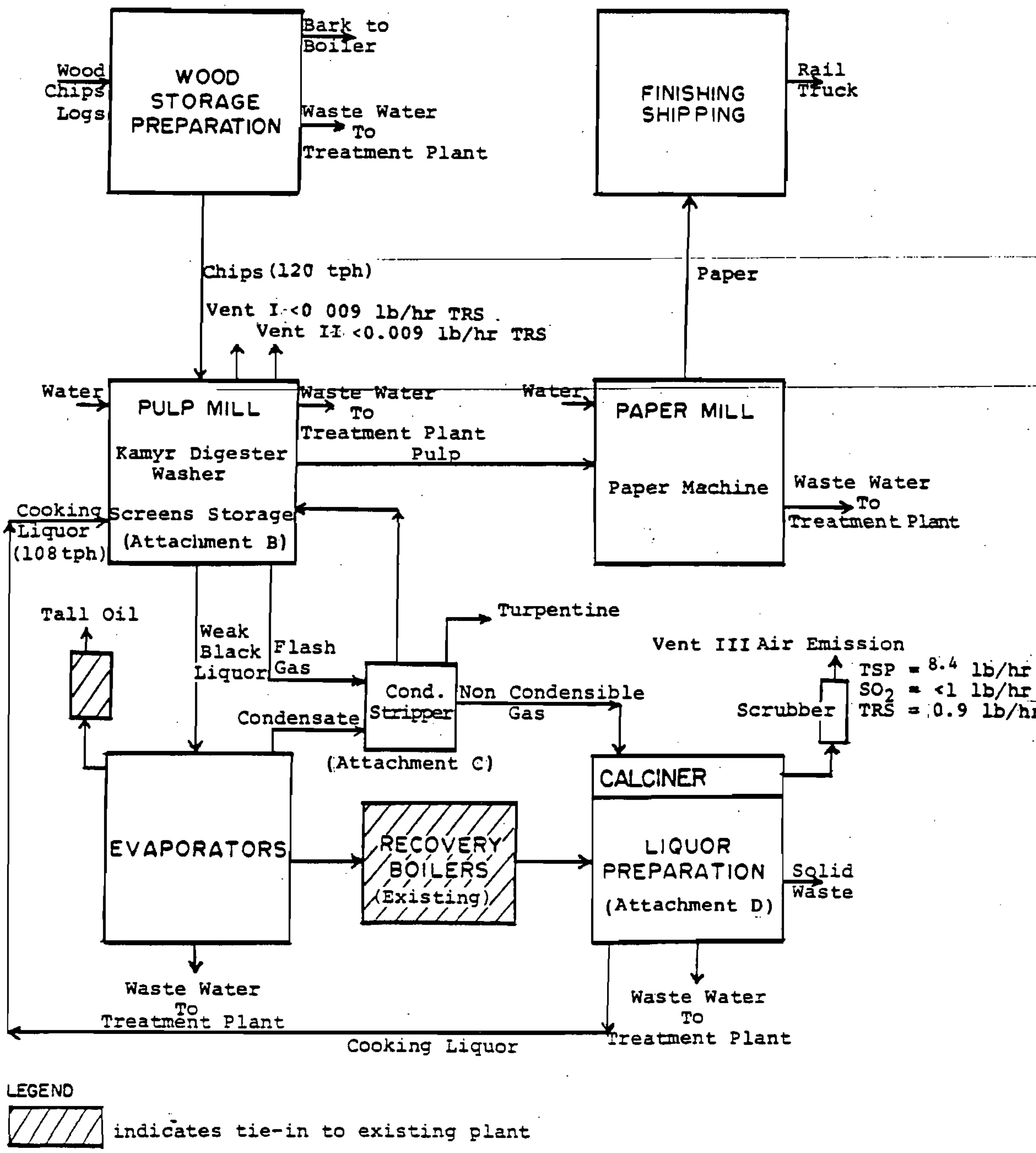
Additional facilities will be added for condensing and decanting the estimated 1,190 gallons of additional turpentine to be recovered. The existing Tall Oil Plant will produce the estimated additional 55,000 lbs. of crude Tall Oil anticipated.

Evaporation of Black Liquor

A new sextuple line of evaporators will be added with two concentrators to thicken the additional black liquor produced. A separate soap skimmer is provided to reclaim the soap for the Tall Oil plant. Three additional storage tanks will be provided for storage of black liquor.

PENSACOLA PAPER MILL
FLOW SHEET

FIGURE I



Causticizing and Lime Recovery

In order to produce the additional cooking liquor for the pulping process, new facilities for liquor clarification, causticizing, lime mud washing and storage are provided.

A new Fluo-Solids Calciner of 125 ton per day capacity will be added to burn the lime required. It will be equipped with a venturi-type dust scrubber.

Noncondensable System

A conventional system will be provided to burn, in the Lime Kiln or Calciner, the noncondensible gases from the new digester, condensate stripper and evaporators to remove the TRS.

A steam stripper will be provided to remove contaminants from the evaporator condensate and allow for re-use of the water in process, thus reducing the effluent discharge quantity.

Paper Production

A new paper machine with associated facilities for stock blending and refining will be added. This machine can produce up to 800 tons per day of paper depending on the grade being made. All paper will be unbleached.

Auxiliary equipment will provide pulping facilities for waste dry paper and filtering to salvage fibers from the machine effluent water. The clarified water will then be recycled for use in stock blending, refining and showers on the machines. Maximum re-use of water will minimize the quantity of effluent discharged to the treatment plant.

Paper Finishing and Shipping

The addition of these new facilities will increase the volume of paper produced by the total mill (existing plus expansion) to 1,300-1,400 tons per day.

Roll finishing for the new tonnage will be provided.

A complete new roll storage facility will be provided. Loading facilities will include multiple rail tracks, each 300 ft. long, and truck loading facilities to accommodate highway trucks along with loading aisles.

Power

New turbine generators will be provided that will replace all existing units. They will generate the total electrical power needs of the mill and discharge steam at lowered pressures for mill process use.

Water Supply

The mill is presently supplied with water from wells on the property. Current usage is 22 to 25 million gallons per day. There is no anticipated water required above the 25 million gallons per day.

Waste Treatment

The existing mill waste treatment system is a series of ponds which provide secondary treatment which meets the limits of current Federal NPDES and State of Florida Permits. No changes will be made to the existing treatment system.

Solid Waste

Solid waste consisting of fly ash, waste treatment sludge, excess bark, green liquor dregs and cooling tower sludge is now put into a disposal area on company property. The additional waste generated by the new facilities will be put into the same area.

Integration with Existing Facilities

The expansion project as now proposed will be integrated into many of the existing facilities at the present mill site. One of the key items in this process is the Recovery Boiler in which the black liquor solids are burned to produce steam and recovery chemicals. No new Recovery Boilers are being added at this time. The existing Recovery Boiler capacity will handle the black liquor solids from the expansion project as well as the existing mill.

Resource Requirements

Raw Materials

The major raw material is wood. The requirements for this project are 280,000 cords per year of pine pulpwood.

Other raw materials required are chemicals as follows:

Salt cake	5,200 tons/year
Lime	2,600 tons/year

Material Balance (for 750 air dried tons per day)

	Avg.
Wood cords/day	1,334
Pulp Mfg. ton/day	750
Turpentine gal/day	1,588
(1.19 ga/cd wood)	
Tall Oil lb/day (55 lb/cd)	73,370
Paper Mfg. ton/day	700
Sulfuric Acid lb/day	15,774
(430/ton oil)	
Salt Cake ton/day	27.7
(p-74) lb/ton	
Lime ton/day	11.6
(p-31) lb/ton	
Green liquor dregs lbs/day	9,000
(12 lb/ton pulp)	
Waste Treatment Sludge lb/day	60,000
(129,200 @ 92.8% removal 1977)	
(then 50% for new tonnage)	

Fuel Utilization

Natural gas consumption for power generation will be reduced by this project.

Emission Points

There will be a single air emission point for the entire process outlined (The Calciner Stack).

1. All off gas discharges from the Digester System and Evaporators which contain TRS in excess of 5 ppm will be treated in the Condensate Stripper.
2. Noncondensible gases from the Condensate Stripper will be incinerated in the calciner.
3. The calciner will be equipped with a venturi scrubber to remove particulate to the process and minimize the discharge to the atmosphere.

ATTACHMENT B

KAMYR CONTINUOUS DIGESTION AND WASHING SYSTEM

This system incorporates continuous digestion of the chips into pulp with digester washing followed by two stage diffusion washing. A brief description of the process is as follows (see attached):

Chip Bin (1)

Open top bin to hold reserve supply of chips, also to collect knotter rejects.

Steaming Vessel (2)

Chips are fed into steaming vessel through special feeder where fresh steam and/or steam from No. 1 Flash Tank is added. This vessel is vented to the Condensate Stripper System.

Pre-Impregnation Vessel (3)

Chips and cooking liquor are fed into top of this vessel which is operating under hydrostatic pressure. The chip-liquor mixture exits at the bottom.

Continuous Digester (4)

The chip-liquor mixture is fed into the top of the digester, steam is added and the chips move toward the bottom of the vessel. For the in-digester washing, liquor from the diffuser washer filtrate tank is added at the bottom of the digester. This wash water - black liquor is removed from the digester at about the middle of the vessel. The chips are cooked in the top half of the vessel and the first washing stage is in the bottom half of the vessel. The black liquor removed at the middle of the vessel is sent to the Flash tank. Relief gas from the digester top is sent to the Condensate Stripper System.

Diffusion Washer (5)

Partially washed pulp from the digestor flows to the two stage Diffusion Washer. The pulp is washed with two stages of wash water. The pulp from the second stage is thoroughly washed and goes to the High Density Storage Tank.

Second stage wash water is used to wash in the first stage. First stage wash water goes to the digester for the digester washing stage.

This Diffusion Washer is vented to the atmosphere. Data from installations in the U.S. and Sweden indicates TRS at levels of 1-2 ppm in the vent gas. Vent I will emit less than .009 lb./hr.

Filtrate Tanks (6)

Water from the two stages of washing goes to a two stage filtrate storage tank. This tank is vented to the atmosphere to avoid collapse under vacuum conditions. Since the diffusion washer is operated with the pulp completely submerged there is no entrained air to be released from the liquor at this point and since the tanks are operated at constant level there is little or no vent gas released. Vent II will emit less than .009 lb/hr. of TRS.

Screening

From the High Density Storage Tank the pulp is diluted and pumped to the knotter. This is a completely closed unit and since the pulp is thoroughly washed there are no TRS gases evolved in the screening process.

Air Emission Sources

The air emission sources from this system are as follows:

1 - Steaming Vessel - gas to Condensate Stripper System

2 - Digester Relief - gas to Condensate Stripper System

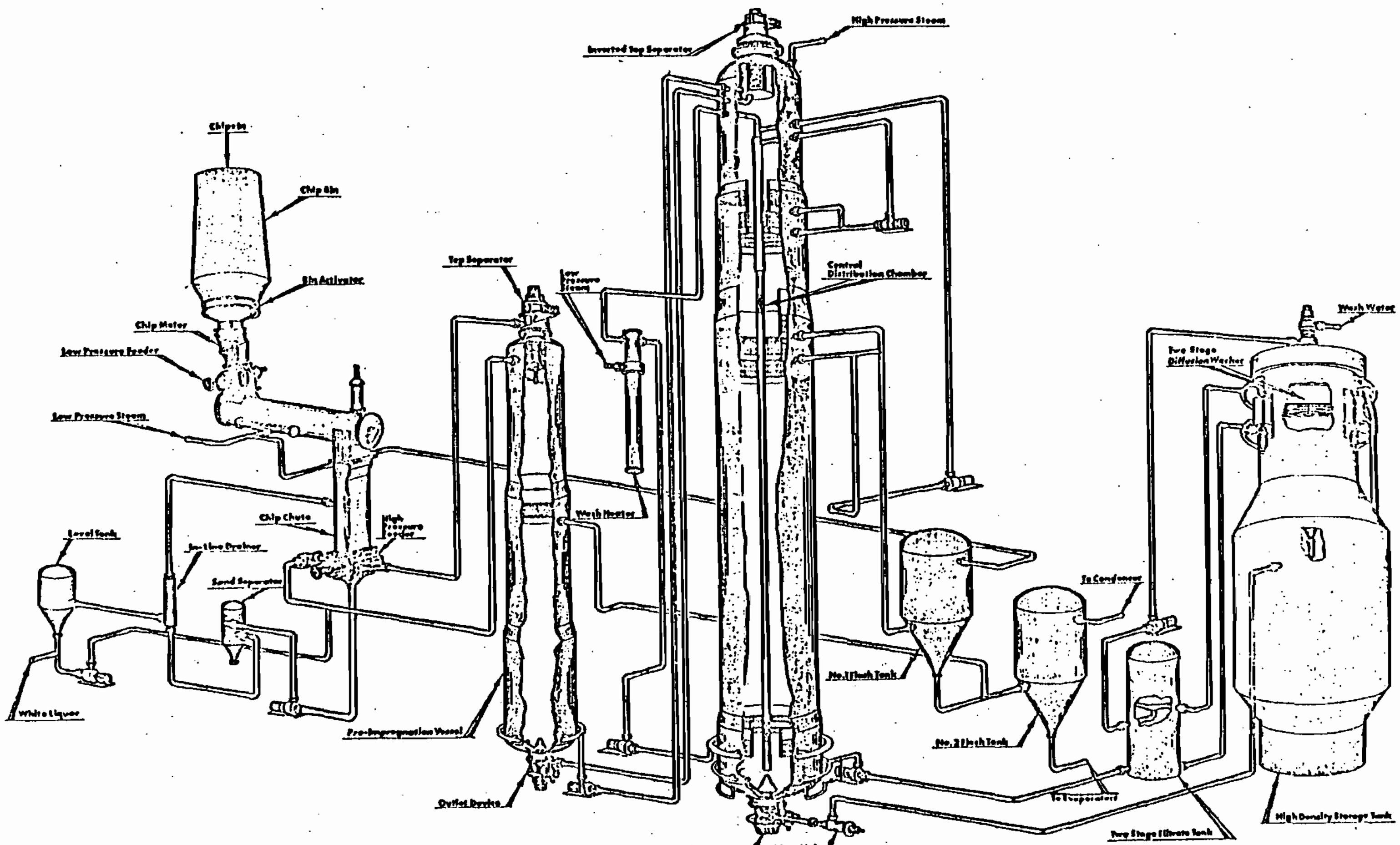
3 - No. 1 Flash Tank - gas to steaming Vessel or Condensate Stripper System

4 - No. 2 Flash Tank - gas to condensate Stripper System

5 - Diffusion Washer - Vent to atmosphere less than 2 ppm TRS (Vent I)

6 - Filtrate Tanks - Vent to atmosphere, little or no flow (Vent II)

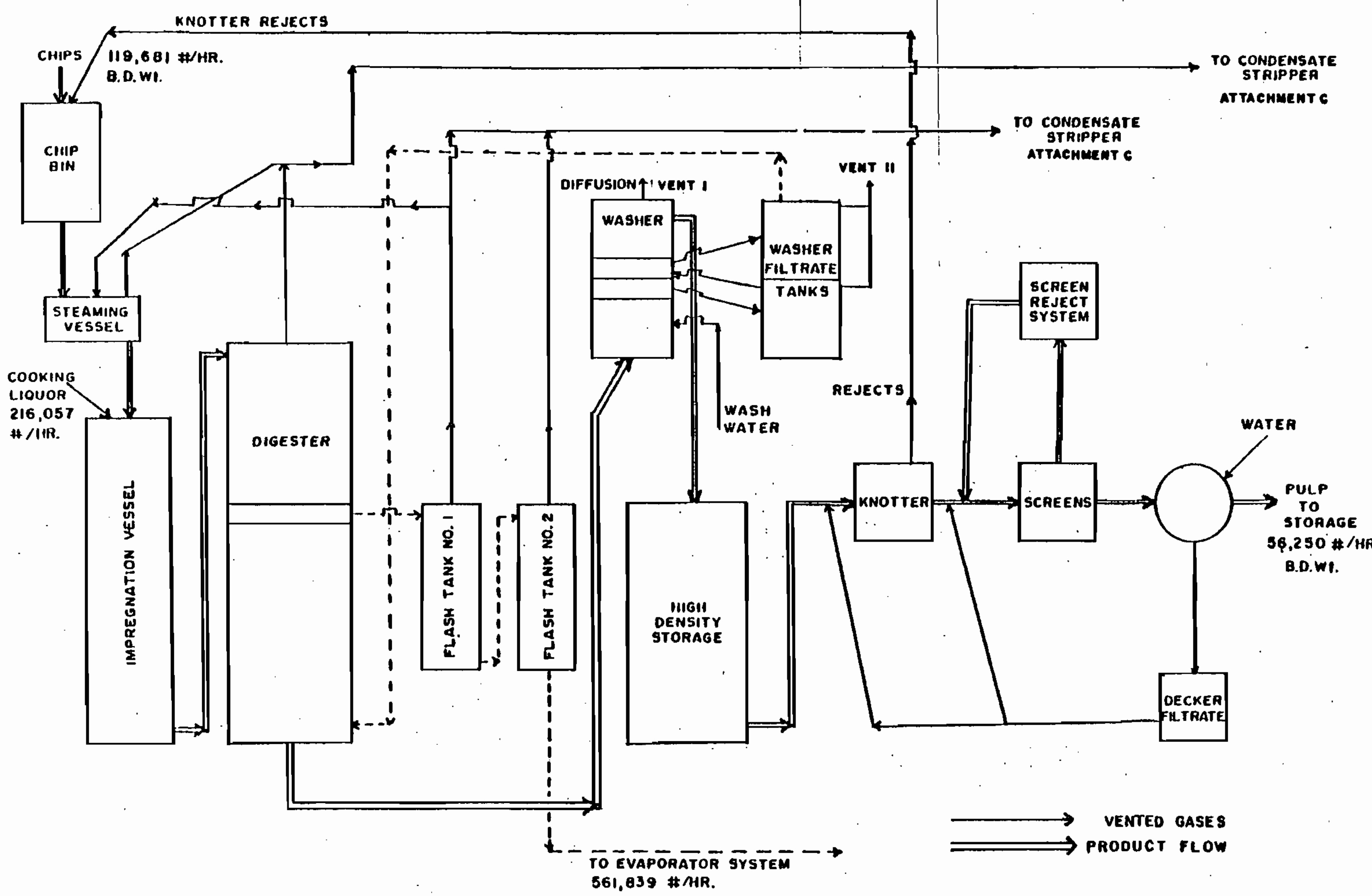
7 - Knotter - no vent



Kamyr Two Vessel System
With Two Stage Diffusion Washer

BEST AVAILABLE COPY

KAMYR-DIGESTER-WASHING-SCREENING SYSTEM



KAMYR INCORPORATED

GLENS FALLS · NEW YORK 12801 · U·S·A·

CABLES-KAMYRINC   TELEX-145474   TELEPHONE (518) 793-5111

920
April 27, 1979

Mr. D. M. Ferguson
St. Regis Paper Co.
Corporate Engineering
2400 Gulf Life Tower
Jacksonville, Florida 32207

Dear Don:

In reply to your request today to our Mr. Sherman, enclosed is information on emission of odorous gases from the Kamyr diffuser washer at Louisiana Pacific's Antioch mill and a Kamyr diffuser washer in Sweden.

In both cases the TRS emissions are extremely low and are not collected or treated.

Yours truly,

K A M Y R, I N C.

Carl Elmore

CLE:ehp
Encs.
cc: M. I. Sherman

M E M O R A N D U M

TO: O. A. Laakso

DATE: December 13, 1974

FROM: F. R. Kintzing

cc: M. I. Sherman
J. R. Phillips
T. E. Jenkin
J. J. Nelson
R. H. Collins
W. C. Glacy
L. E. Gazdik
R. L. Purdy

SUBJECT: Diffuser Emissions To Atmosphere

I received the following data from Harry Wolfe of Fibreboard regarding air pollutants released from their Kamyr Brown Stock Diffuser:

Hydrogen Sulfide	-	0.65 - 0.80 ppm
Methyl Mercaptan	-	0.16 ppm
Di-Methyl Sulfide	-	0.13 - 0.18 ppm

Velocity of gases from cover vent - 1' to 2' per minute.

The above values were obtained from two (2) observations.

This information may be an increasingly important sales tool as air pollution abatement regulations profilerate.

Reese
Reese

FRK/dh:3480

66028 KAMYR S

1975.02.20 BE/4333/EJ

ATTENTION MR F R KINTZING

RE: EMMISSIONS FROM DIFFUSER*

FURTHER TESTS HAVE NOW BEEN MADE AT THE DIFFUSER
MENTIONED IN MY TELEX OF 19.12.1974

THE FIGURES GIVEN BELOW ARE AVERAGES FROM SEVERAL TESTS AND
THEREFORE QUITE RELIABLE.
ALL COMPONENTS EXPRESSED AS MILLIGRAMS PER NORMAL CUBIC
METRE
H2S : 2, DMS:33, MM 16 AND DMDS BELOW 5.
THE GAS VOLUME WAS 31 CUBIC METRES PER ADMT OF PULP.

BEST REGARDS
KAMYR/BROR EK

* These are the emissions which go to the non-condensable gas system.

TLX VIA ITT DIAL 103 [illegible] 303

VIA WUI+

KAMYR GLF

1974-12-20 BE/4333/EJ

ATTN MR F R KINTZING

RE EMISSIONS FROM DIFFUSERS*

A SINGLE TEST HAS BEEN DONE REGARDING THIS MATTER IN
A SWEDISH MILL
THIS MILL HAS A CONTINUOUS DIGESTER FOR BASE LINER WITH
50 MINUTES HI-HEAT FOLLOWED BY TWO DIFFUSERS IN SERIES
AND THEREAFTER TWO FILTERS IN PARALLEL
THE TEST WAS DONE AT THE FIRST DIFFUSER WHERE THE OUT-
GOING SALT CAKE CONTENT IS AROUND 60 KGS NA2SO4/ADMT.
THE FOLLOWING RESULTS WER E RECORDED:
DMS: 525, DMDS BELOW 10 AND MM BELOW 7. THE FIGURES
ARE GIVEN AS MILLIGRAMS OF THE COMPOUND PER NORMAL
CUBIC METRE
THE GAS VOLUME IS 6 NORMAL CUBIC METRES PER ADMT OF PULP
FURTHER TESTS WILL BE DONE AT THE END OF JANUARY

REGARDS
EROR EK/KAMYR

---

* These are the emissions which go to the non-condensable gas system.

ATTACHMENT C

NONCONDENSIBLE GAS SYSTEM

Noncondensible Gases which are the TRS emissions will be incinerated in a Fluo Solids Calciner.

Emissions from 1 - Steaming Vessel

2 - Digester

3 - Flash Tank 1 and 2

will go to the Condensate Stripper System.

Condensate from 1 - Evaporators

will go to the Condensate Stripper System.

From the Condensate Stripper System

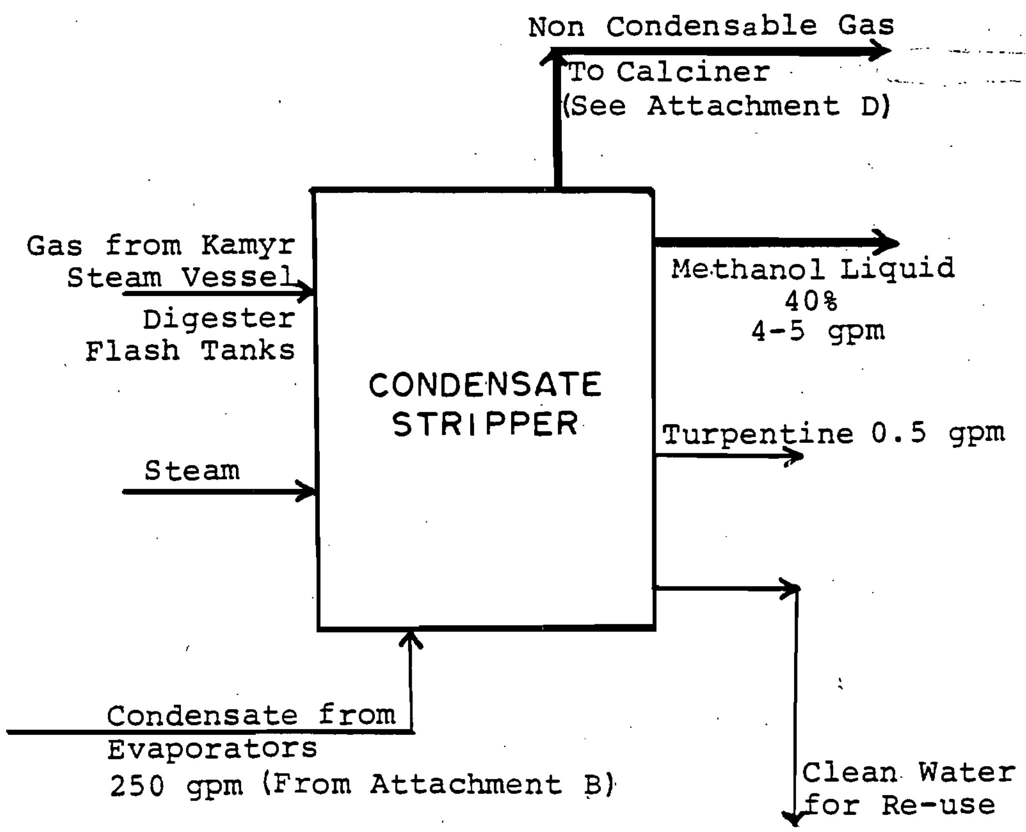
Noncondensable Gases will be incincerated.

Methanol solution will be incinerated.

Condensate will be used for wash water.

Turpentine will be collected as by-product.

PENSACOLA PAPER MILL
CONDENSATE STRIPPER



DORR-OLIVER INCORPORATED

PROCESS DESCRIPTION

The FluoSolids Lime Mud Reburning System basically consists of a two-stage process. . . drying and calcination. The operation of the drying system is as follows: Washed lime mud from the causticizing system is pumped to a lime mud storage tank. Lime mud is metered to the filter through a magnetic flow meter and an automatic control valve. Hot water wash is applied to the cake via spray headers as required for final control of the alkali content of the lime mud.

A screw conveyor transports filter cake to the paddle mixer where it is mixed with dry recycle calcium carbonate from the primary cyclone, along with a small amount of water as required for control of drying system temperature. The rate of dry solids recycle to the paddle mixer is adjusted by the splitter valve to maintain about 10-15% moisture entering the cage mill along with precooled calciner gases, where the moist solids are dried and disintegrated to a fine powder. The gases sweep the fine dry solids out of the cage mill to the two stage dry dust cyclone collectors.

The dry calcium carbonate feed flows by gravity to a surge bin. This bin is equipped with level indicators to enable the operator to control demand and supply by adjusting input to the calciner or input to the filter in order to maintain a solids balance between the two systems. Gases from the secondary cyclones pass through an induced draft fan and Venturi scrubber before they are emitted to the atmosphere. Scrubber effluent is pumped to the final stage of the lime mud washer for recovery of the hot water for mud washing.

The dry carbonate is pneumatically conveyed to the calcining bed, where it calcines instantly. It then adheres to the pellets in the bed, due to the stickiness of the residual soda. Fuel is injected directly into this bed, where it burns on the particle surfaces, maintaining the temperature at 1600°F. The calcined particles are discharged automatically by a level controller into the cooling bed, where they are cooled to approximately 600°F by the incoming air. A similar level controller on the cooling bed automatically discharges the cooled product to the product elevator.

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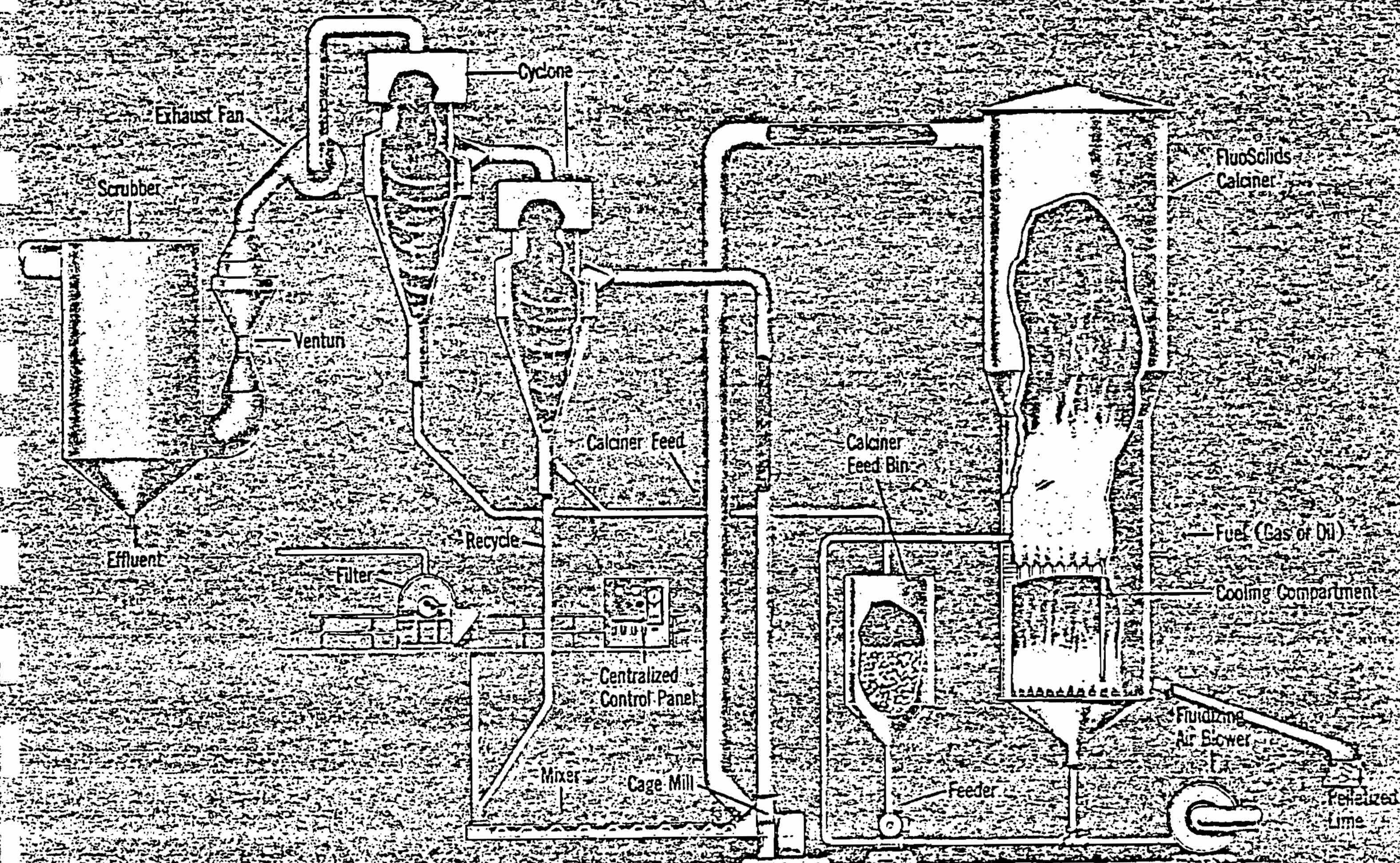
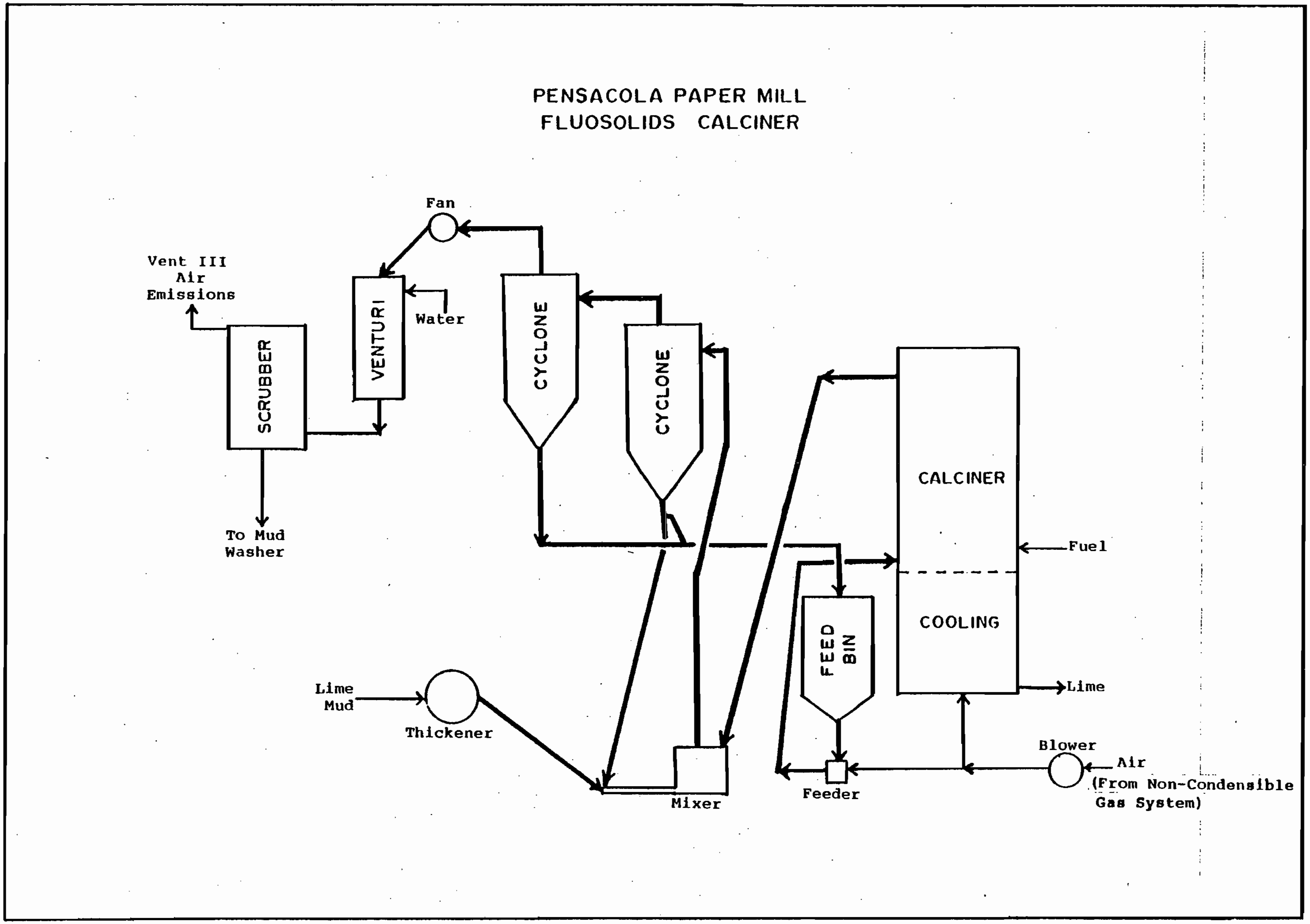
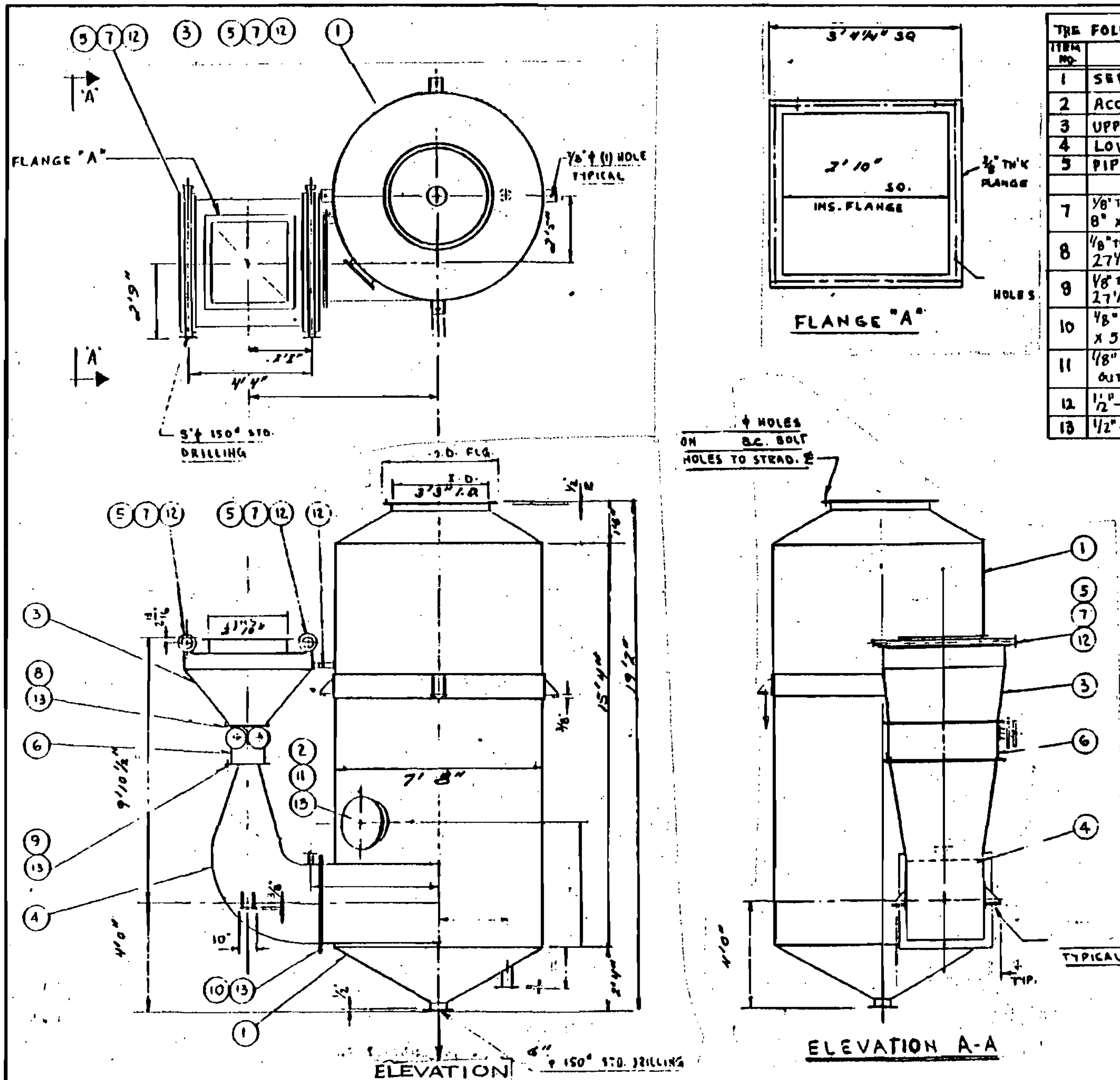
FLUOSOLIDS



DORR-OLIVER FLUOSOLIDS LIME MUD REBURNING SYSTEM


PENSACOLA PAPER MILL
FLUOSOLIDS CALCINER
Fan
Vent III
Air
Emissions
VENTURI
Water
SCRUBBER
CYCLONE
CYCLONE
To Mud
Washer
CALCINER
Fuel
COOLING
FEED
BIN
Lime
Lime
Mud
Thickener
Blower
Air
(From Non-Condensible
Gas System)
Mixer
Feeder



THE FOLLOWING ITEMS APPEAR ON MAT'L. LIST Nº J-7204 ML I			
ITEM NO.	DESCRIPTION	PART No.	QTY
1	SEPARATOR	1-8064-A	1
2	ACCESS DOOR	1-8064-B	1
3	UPPER VENTURI	1-8055-A	1
4	LOWER VENTURI	1-8055-B	1
5	PIPE HEADER	1-8055-C	2
7	1/8" THK. F.F. GSKT. 2 3/8" x 78 3/8" INS. 8" x 81 3/4" OUTS. J.M. # 101	———	2
8	1/8" THK. F.F. GSKT. 20 3/8" x 68 3/8 INS. 27 1/8" x 74" OUTS J.M. # 101	———	1
9	1/8" THK. F.F. GSKT. 11 1/2" x 68 1/8" INS. 27 1/8" x 74" OUTS. J.M. # 101	———	1
10	1/8" THK. F.F. GSKT. 49 3/8" SQ. INS. x 55 3/8" SQ. OUTS. J.M. # 101	———	1
11	1/8" THK. F.F. GSKT. 20" ⌀ INS. x 25 1/2" ⌀ OUTS. J.M. # 101	———	1
12	1/2"-13NC x 1 1/4" LG. HEX. HD. BOLT & NUT	———	86
13	1/2"-13 NC x 1 1/2" LG. HEX. HD. BOLT & NUT		168

THE FOLLOWING ASS'Y APPEARS ON MAT'L LIST Nº J-7204 ML I			
ITEM NO.	DESCRIPTION	DWG. NO.	QTY
6	ADJUSTABLE THROAT ASS'Y	1-8056	1

SCRUBBER ASSEMBLY

DORRCO FLUOSOLIDS SYSTEM

PERFORMANCE GUARANTEE

Size No. 15

Seller guarantees as and to the extent hereinafter set forth that, after the operation has been stabilized and the operators have acquired reasonable skill, the system will be capable of producing the results as set forth in "1" below when using the raw materials (furnished by the Buyer), set forth in "2" below, provided that Buyer furnishes a complete, adequate and competent operating, laboratory, supervisory and maintenance staff and the system is erected, installed, operated and maintained in accordance with Seller's instructions.

1. Guaranteed Results

   a. The calciner will be capable of producing 125 tons of lime product per 24 hours.

   b. The total loss of solids (expressed as $CaCO_3$) and sodium fume (expressed as Na_2O) emitted from the scrubber shall not exceed .067 grains per dry standard cubic foot of flue gas (1 Atm, 70° F), corrected to 10% O_2.

   c. When operating at designed capacity, the heat requirement of the installation will not exceed 7.5 million BTU net per ton of product when operating on No. 6 oil and product contains 85% available CaO.

   d. The installation will produce a gaseous discharge containing 5 ppm or less of total reduced sulfur compounds. (Expressed as H_2S)

2. Raw Materials Supplied By Buyer

   a. Required quantities of wasted lime mud from the final stage of Buyer's filter at a solids concentration of not less than 65%, containing not more than 0.3% total titratable alkali as Na_2O (dry basis), nor more than 0.5% total alkali, and not less than 92% $CaCO_3$ (dry basis).

   b. The lime mud shall not contain more than 0.5% free CaO on a dry basis.

ATTACHMENT E

SUPPLEMENTAL DATA

FOR CALCINER

Keywords
Causticizing
Calcining*
Fluidized bed
Furnaces
Lime
Clarifiers
White liquor mud
White liquors
Green liquors

Abstract
Recausticizing and lime reburning are often neglected areas of the pulp mill, yet liquor making is vital to pulping. Proper operation of this area can have quite an effect on the overall economics of the pulp mill. The paper reviews the design of the modern recausticizing system, describes some common operating problems and their solutions, and provides information on the operation of a fluidized bed lime calciner.

The modern recausticizing and lime calcining system

Lee M. Bingham and Peter A. Angevine

Recausticizing, although frequently considered the tail end of the mill, is the economic backbone of the kraft process. While recausticizing today is much the same as ever, there have been several recent equipment innovations intended to increase economy in the face of constantly rising costs for caustic soda and to reduce emissions in keeping with growing environmental restrictions.

The role of the recausticizing system is to provide uniform white liquor for the digesters while recovering the greatest amount of soda possible from the lime mud and producing a mud that can be reburned efficiently and economically. Furthermore, there should be no effluent from a well-operated recausticizing system.

The modern recausticizing system (Fig. 1) consists of green liquor clarification, dregs washing, slaking, causticizing, white liquor clarification, lime mud washing, and lime mud filtration. Rather than detail the operation of such a system, which is quite well known throughout the industry, this paper focuses on several of the more interesting developments of recent years in recausticizing, assesses their significance, and reviews some of the more common problems. An update on the operation of a 10-year-old fluidized bed recausticizing system is included.

L. M. Bingham, P. H. Glatfelter Co., Spring Grove, Pa. 17362; P. A. Angevine, Dorr-Oliver Inc., 77 Havemeyer Lane, Stamford, Conn. 06904.

EQUIPMENT DEVELOPMENTS

One of the more significant trends today is the use of unit-type clarifiers with liquor storage above the clarification compartments for clarifying green and white liquors and for lime mud washing. Unit clarifiers have lower initial cost than multicompartment machines and eliminate the need for separate liquor storage tanks, which saves on tank cost, floor space, piping, and foundations for separate tanks.

A second equipment innovation of note is the growing use of vacuum filters for dregs washing. There are three types of filter used in this application: a belt filter, a drum filter with or without lime mud added, and a precoat filter using a lime mud precoat. Of the three, the precoat filter seems to be the most attractive. It tends to produce a drier cake with improved washing efficiency while consuming a minimum of lime mud. Equipped with an automated cake-doctoring system, today's modern precoat filter can yield a cake of over 75% solids, depending on lime and lime mud quality.

OPERATING PROBLEMS

When it comes to problems in recausticizing, it is important to stress that a well-operated system will have few problems so long as the operator keeps all parameters within allowable limits. However, because all stages of the system are interrelated, if there are problems, they tend to surface far downstream at the lime mud filter. This is a key unit operation, and its performance will affect fuel consumption in the lime calciner. Whether the calciner is a rotary kiln or a fluidized bed unit, poor filter operation can cause a considerable waste of energy in the calcination process.

However, when recausticizing system problems do arise, it has been our experience that they can be attributed to any one or a combination of the following conditions: (a) poor green liquor clarification, (b) improper slaking temperature, (c) low-quality lime, (d) free lime in the lime mud, and (e) undersized lime mud filter.

Poor Green Liquor Clarification

Poor green liquor clarification is usually caused by using too small a clarifier, although there are several mills today operating their recausticizing systems without any green liquor clarifier. This clarifier is a last chance to remove impurities from the liquor system, and this opportunity should be taken advantage of for the sake of overall system efficiency. Very often even a low percentage of dregs in the mud can severely affect filter performance. A constant inert buildup in the mud circuit also lowers lime availability, which causes even more fuel consumption.

Another problem with green liquor clarifiers is intermittent dregs pumping—a practice that causes poor soda recovery. A solution to this problem is the use of a pump, such as an air-operated diaphragm pump, that assures that the slurry will be pumped at low average flow rates and that prevents the settling of suspended solids in the piping.

Operators also should be aware that flocculants are not necessarily a miracle cure. A properly designed green liquor clarifier does not require flocculants for optimum operation. If the clarifier becomes overloaded, they may be helpful, but care should be taken to check for undesirable side effects downstream.

Improper Slaking Temperature

When the slaking temperature is too low, the mud becomes granular, and the white liquor will be turbid. Also, the causticizing reaction may not be completed. Of course, too high a temperature will result in a boil-over. Control of the slaking temperature requires uniform green liquor strength and temperature.

Low-Quality Lime

Improperly reburned limes are less reactive than purchased limes and tend to slow down the causticizing reaction. Impurities in the lime mud, such as silica and magnesia, affect the reaction rates, settling rates, and filtering operation. By using the highest-quality lime available, the mill can prevent many headaches later on.

Free Lime

Free lime problems have several causes, one being the storage of purchased lime and reburned lime in the same bin. Since the lime is metered by a screw, there is a constantly varying amount of lime fed to the slaker, and it is impossible to control the lime–liquor ratio when both are stored in a single bin. A two-bin system, with a constant, controlled flow of purchased lime from one and reburned lime from the other is a necessity, not a luxury. In the two-bin system at P. H. Glatfelter, the problem has been solved by adjusting the flow of purchased lime to a constant rate that matches the mill make-up requirements. The flow of re-

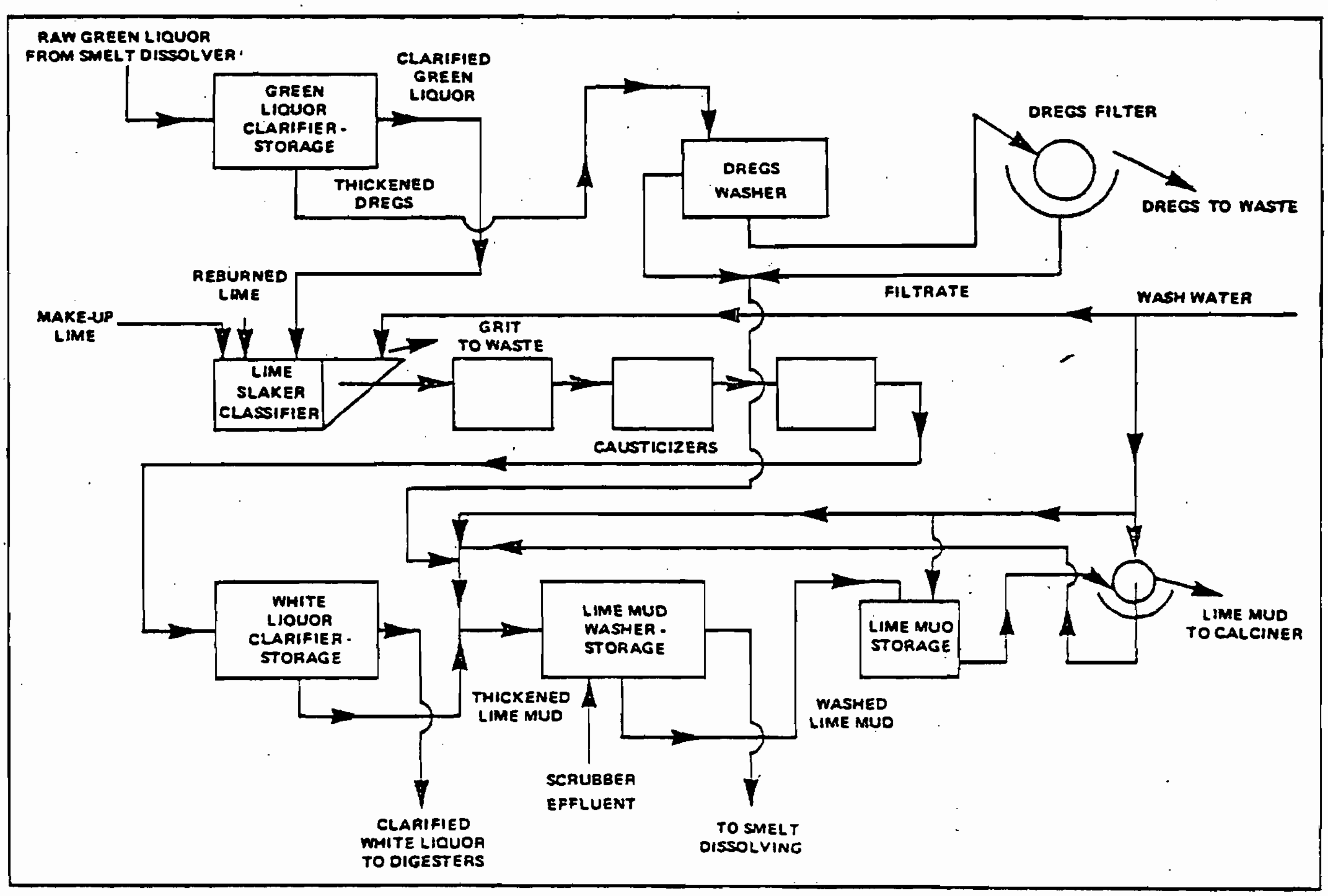


Fig. 1. Recausticizing flow chart.

burned lime is then adjusted to maintain the desired causticizing conversion. Only minor adjustments in lime flow are required. In most instances, a constant flow of purchased lime also prevents the system from operating totally on this material. Many operators have experienced severe filtration problems when operating solely on purchased lime.

Another cause of over-liming is variations in the strength of the green liquor. At Glatfelter, we have found that maintaining a constant level for "A" titration is important to the proper operation of the recausticizing system.

Still another cause of over-liming is a misunderstanding of what is a reasonable target for causticizing conversion. Figure 2 shows that the equilibrium conversion is a function of the sulfidity as well as of the total titratable alkali. It is important to choose the correct equilibrium for each mill.

Why is free lime such a problem? It settles very poorly in the clarifiers and creates even worse problems on the lime mud filter. A typical settling curve for lime mud solids is shown in Fig. 3. This graph also shows a settling curve for mud containing 7% excess lime. There is a dramatic difference between the two curves, which clearly illustrates the effect of overliming. A settling test should be used as a quick check for free-lime content, and many mills do use this method as a control procedure. The most common target for this test is 50% volume in 5 min for a sample taken

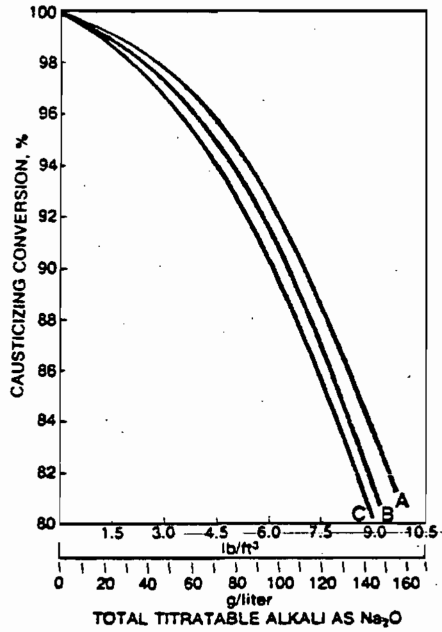


Fig. 2. Equilibrium causticizing conversion vs. titratable alkali. Line A: pure sodium carbonate. Line B: 30% sulfidity; Line C: 30% sulfidity.

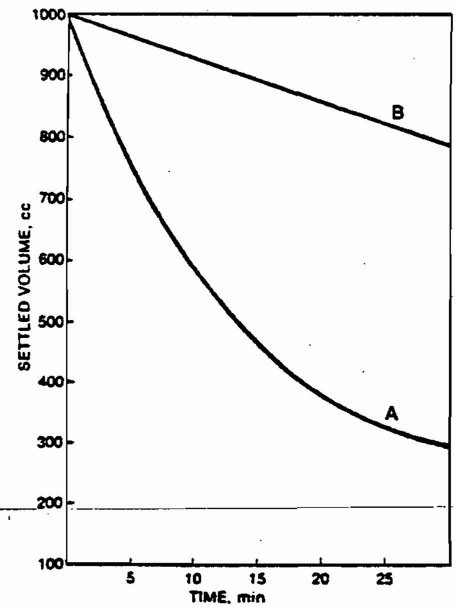


Fig. 3. Line A: typical settling curve for lime mud solids. Line B: settling curve for mud containing 7% excess lime.

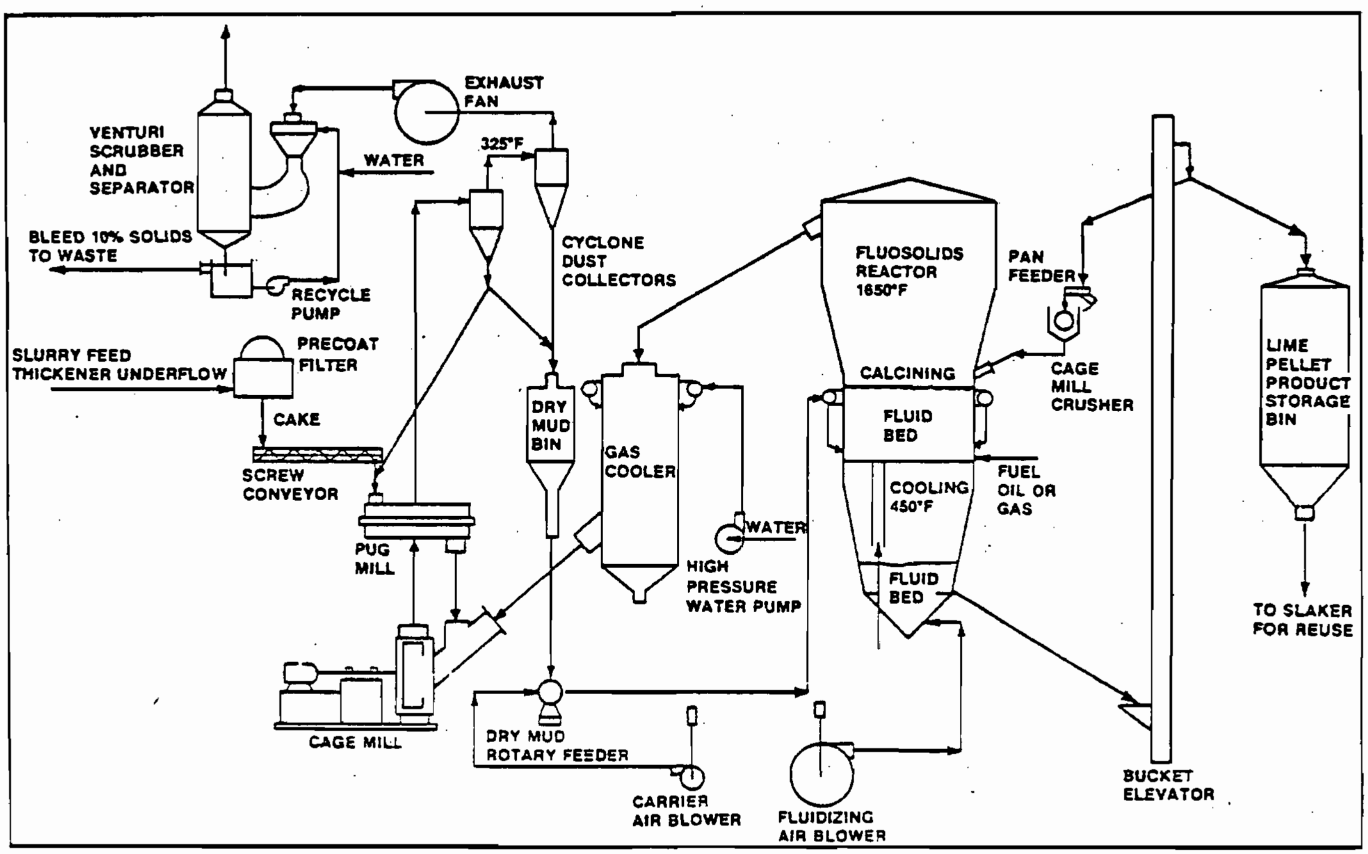


Fig. 4. Schematic of Glatfelter's fluidized bed calciner.

Table I. Particulate Emissions From Fluidized Bed Calciners

Mill	Fuel type	Capacity, tons/day	Emissions, mg/Nm³	Emissions, gr/dry std ft³
Glatfelter	No. 6 oil	136	170	0.069
S. D. Warren[a]	No. 6 oil	63.5	25	0.010
Westvaco[b]	Natural gas	136	116	0.047

[a]Moran, J. S., and Wall, C. J., *Tappi* 49(3): 89a (1966). [b]Byerly, J. W., "Comparison of TRS and Particulate Emissions from a Conventional Lime Kiln with Those from a FluoSolids Calciner," presented at NCASI Southern Regional Meeting, Atlanta, Ga., 1976.

Table II. Fluidized Bed Calciner TRS Emissions

Mill	TRS, ppm		Scrubbing system make-up water
	Before scrubber	After scrubber	
Glatfelter	0	0	Fresh water
Westvaco[a]	5.9	3.9	Fresh water

[a]Byerly, J. W., as Table I.

from the slaker or first causticizer. A hazy supernatant is also indicative of free lime. This simple test helps the operator to adjust the lime–liquor ratio to maintain a good operation. Some mills use other specifications, depending on the type of lime and the dregs content. It is simple for each mill to determine the proper settling target for its particular operation.

Lime mud that settles properly has an important benefit: clear white liquor. By eliminating free lime, white liquor clarity is improved, and this results in fewer shutdowns for descaling the digester, which means substantial savings in operating costs.

Too Small a Lime Filter

It is unwise to skimp in filter sizing, especially since mechanical dewatering is cheaper than evaporation. The evaporation of water from a filter cake of 60% solids content requires 197,000,000 J (1,700,000 Btu) more energy than it takes to remove the water from a 75%-solids-content cake. Also, as the moisture in the lime mud fed to a rotary kiln increases, the total reduced sulfur (TRS) emission also increases. To assure that the lime mud filter is properly sized, it is important to check all aspects of the overall system as they affect the filter so that the size filter ultimately chosen will reflect the amount of washing to be performed by the machine.

THE CALCINER

Because the efficiency of the recausticizing system depends to a large extent on the quality of lime produced by the lime reburning system, it would be useful to review the experience of Glatfelter with the Dorr-Oliver FluoSolids calciner installed some 10 years ago.

This calciner is a 136-metric-ton/day unit (150-ton/day) (Fig. 4). Specific details on the startup and operation of the system were covered in two earlier papers.[1,2] What follows then is an update on the performance of the system accompanied by data from similar installations.

The fluidized bed calciner was selected over the traditional rotary kiln for the following reasons:

- Reduced emission
- Low fuel requirement
- Uniform-quality product
- Low maintenance
- Long refractory life
- High level of flexibility
- Minimum space requirement.

The system takes wet filter cake and dries it in an external flash drying system. The dry powder is then blown into the calciner where it reacts instantly at a temperature of 870–900°C (1600–1650°F). Fuel is No. 6 oil. The fine (< 30 μm) mud particles then agglomerate to pellets ranging from 6 to 65 mesh. A bed level controller automatically discharges the product to a cooling bed, and a similar controller discharges the cooler to a 136-metric-ton (150-ton) product bin.

Emissions

The flash drying system utilizes primary and secondary cyclone collectors followed by a venturi scrubber operating at a pressure drop of 46.0–58.5 cm (18–23 in.) of water. A 260-kW (350-hp) electric motor drives the exhaust fan, which is equipped with an adjustable throat to maintain the pressure drop.

The proposed EPA guidelines for particulate emissions are 320 mg/Nm³ (0.13 gr/dry std ft³) for oil-fired units and 165 mg/Nm³ (0.067 gr/dry std ft³) for gas-fired units. Particulate emission data from three fluidized bed calciners are presented in Table I.

These test data are well within the proposed EPA guidelines. Similar comparisons between rotary kilns and fluidized bed calciners often note the greater electric power consumption of a fluidized bed. However, when rotary kilns are equipped with equivalent scrubbing systems, the electric power requirements become much closer in value.

The proposed EPA guidelines limit the TRS emission from lime kilns to 5 ppm. In a fluidized bed calciner, the lime mud from a precoat filter is dried in an external dryer at a temperature of 150–175°C (300–350°F). This is sufficiently low to avoid volatilization of TRS compounds. The dry lime mud is then injected into the calciner where the sulfur compounds are oxidized and the sulfur dioxide is scrubbed by the lime in the bed. The oxidized sulfur compounds are mainly calcium sulfate, which reacts with the green liquor in the slaker to form sodium sulfate.

Stack test data taken from two fluidized bed calciners are presented in Table II. These data show that it is possible to meet the proposed EPA guidelines with a fluidized bed calciner without the use of caustic. The lack of measurable TRS from the Glatfelter calciner has been attributed to the high degree of mud washing. The soluble soda expressed as sodium oxide in the mud leaving the precoat filter is ≤0.30%. These low soda concentrations are obtained through the use of a three-stage mud washing system ahead of the precoat filter.

Fuel Requirements

In Table III, operating data for a typical month are summarized. The fuel requirement was 914,000,000 J/ton (7,900,000 Btu/ton) of product at 84.4% available CaO. There are two factors responsible for the high fuel requirement. First, it has been necessary to keep the calcining temperature at 913°C (1675°F) instead of 871°C (1600°F) in order to compensate for lower solids coming out of the precoat filter. Secondly, the design tonnage of 136 metric ton/day (150 ton/day) is not being attained because of lime requirements. Data previously presented[1] indicate a fuel requirement of 856,700,000 J/ton (7,400,000 Btu) at 136 ton/day and 871°C (1600°F) in the calcining zone.

Product Quality

The quality of product as measured by the percentage of available CaO was

[1]Bingham, L. M., *Tappi* 52 (1): 59 (1969).

[2]Bingham, L. M., and Priestley, R. J., "Start-up and Operation of a 150 TPD FluoSolids Calciner," *Proceedings of the Symposium on Recovery of Pulping Chemicals*, Helsinki, 1968.

Table III. Operating Data Summary, May 1977

Number of operating days	31
Availability factor, %	98.4
FluoSolids lime production, metric tons (tons)	3785 (4173)
FluoSolids lime/day, metric tons (tons)	124 (136.8)
Purchased lime, metric tons (tons)	137 (151)
Make-up, %	3
Fuel requirement, J/ton	9.176×10^{8}
Available CaO, %	84.4
Calcining temperature, °C (°F)	913 (1675)
Drying system temperature, °C (°F)	150 (300)

Table IV. Pellet Size Distribution for Calcined Lime Mud

Tyler mesh	*% Retained*
6	1.0
8	15.6
10	29.0
12	42.1
16	66.9
20	83.0
Fines	100.0

84.4% (Table III). System design called for an availability of 87.5% CaO. The difference between design and actual has been attributed to insufficient green liquor dregs-removal capacity and low lime losses. Only 3% purchased lime make-up was required during May.

Another measure of product quality is particle size distribution. A typical size distribution is presented in Table IV. Pellet size is controlled by the sodium content of the filter cake, reseed rate, and sulfur addition. The fine product has a large surface area and is very reactive in the slaker. As a result, a minimum of grits are produced (less than 227 kg/day).

Maintenance

The overall performance of the system continues to require low maintenance. System availability ranges from a low of 94% during those months when the calciner is descaled to a high of 98% during normal operation. Maintenance data for May 1977, which was a typical month, indicate an availability factor of 98.4% (Table III) or 12.2 hr of downtime. Of the 12.2 hr, 4 were scheduled, and the remaining 8.2 were for unplanned outages.

The refractory performance has been good with no extensive repairs in 10.5 years of operation. All indications are that the refractory will last at least another 10 years.

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Reprinted from TAPPI, Vol. 47, No. 11, November 1964

Fluidized Solids Lime Mud Recovery System at S. D. Warren Co.

H. J. HOTZ, SR., P. HINKLEY, and ANDREW ERDMAN, JR.

Initial operation of a fluidized-bed reactor for reburning lime mud promises improved processing and economy. The fluidized solids calcining system produced a dense, dust-free, easily handled granular lime with 90% available CaO. The average fuel consumption with 60% excess air, was 8.1 million Btu/ton of product. If excess air had been only 20%, as normally encountered in FluoSolids fuel burning systems, fuel consumption would have been 7.2 million Btu/ton of product. The temporary high excess air operation is due to unique conditions encountered during this initial operation.

THE FluoSolids[1] process has been successfully used by the Municipal Water Treatment Plant of the City of Lansing, Mich., since 1956.[2]

The prime factors which prompted S. D. Warren Co. to install a Dorr-Oliver FluoSolids lime mud reburning unit are:

1. Compactness of plant. The FluoSolids installation at the Central Mill, which is designed to produce 70 tons/day of reclaimed lime, occupies only 2775 sq ft of floor space (44 ft wide, 63 ft long). The entire causticizing station, which includes both a causticizing plant and FluoSolids lime mud reburning plant, is housed in one building 78 ft wide and 94 ft long and standing 65 ft high.

Installation cost for the FluoSolids plant was less than it would have been for a 150-ft rotary kiln.

2. Dust-free operation. Since the entire dust preparation or drying section is under negative pressure, the dust nuisance common to other processes of this type is eliminated.

3. Neatness of product. The FluoSolids calciner produces a dense, dust-free, granular product which is easily handled by conventional equipment.

4. Premium product. The FluoSolids calciner produces soft-burned, highly reactive pellets which contain a maximum of available lime.

5. Economical operation. Fuel consumption is 8,000,000 Btu/ton, and indications are that this heating requirement will be lowered even further.

6. Low manpower requirements. Operation at the Lansing lime recovery plant requires only one operator per shift.

7. Low maintenance costs. No moving parts are employed in the calciner. Since calcination in a FluoSolids calciner employs low temperatures (1500°F) and slow temperature changes (even under intermittent operation), refractory maintenance is low.

8. Startup and shutdown ease. Bed-draining is not necessary for shutdown. Thus, intermittent operation (run 2 days, shut down for 1 day) is feasible. Experience has shown that it takes only 15 min to shut down the unit hot. Startup time (time elapsed between equipment activation to lime product discharge) does not exceed 30 min.

The FluoSolids lime mud reburning plant is capable of producing 70 tons/day of recovered lime. Initially, however, the plant is being operated at about 45 tons/day of recovered lime, and operation commenced in mid-November 1963.

FLOWSHEET

A generalized flowsheet of the FluoSolids system installed at Muskegon, Mich., is shown in Fig. 1. General principles of fluidization have been described by Brandt, Krause, and Shafer.

The lime mud reburning system is divided into two basic parts. The first is the drying system in which lime mud filter cake is dried to form dry, powdery feed for the calcination reactor. The second part is the calcination system which produces dense pellets of calcined product.

Lime mud from the recausticizing

H. J. HOTZ, SR., Research Associate, P. HINKLEY, Pulp Mill Superintendent, Central Mill, S. D. Warren Co., Muskegon, Mich., ANDREW ERDMAN, JR., Project Development Engineer, Dorr-Oliver Inc., Stamford, Conn.

[1] Registered trademark referring to fluidized-bed processing equipment manufactured by Dorr-Oliver Inc.

[2] Brandt, M. W., Krause, F., and Shafer, M., *Tappi* 47 (5): 137A (1964).

system washed to proper Na_2O content is filtered to 65–70% solids and fed into a paddle mixer with dry recycled fines and quench water. The resultant mixture containing 8–20% moisture is then fed to a cage mill disintegrator along with precooled calciner stack gases at 1000°F. Within the cage mill, the moist solids are dried and disintegrated to a fine powder. The discharge gas sweeps the fine carbonate to a cyclone separator controlled at about 275°F. Part of the dry, powdery solids collected in the cyclone are recycled to the paddle mixer, and part are fed into the calciner feed bin. Cyclone gases are passed through a scrubber before they are emitted to the atmosphere.

The calcination reactor is a two-compartment vessel in which the top bed is for high-temperature calcination of calcium carbonate and pelletization of the calcium oxide, and the bottom bed is for heat recovery. A positive displacement-type blower is used to supply air to the reactor for fluidization, which is also used as combustion air for fuel burning. Part of this air is also diverted to blow (or convey) the powdered calcium carbonate feed to the reactor. Within the reactor, solids and gas flow are countercurrent: the solids flowing downward and the gases flowing upward. The dry carbonate powder feed is metered to an air-swept pipeline and is blown into the bottom part of the calcination bed through a series of "feed guns" located around the periphery of the reactor. Heat to the calciner is obtained by direct bed burning of a fuel which is distributed through "fuel guns" also located around the periphery of the reactor. The calciner at S. D. Warren Co. is equipped to burn either heavy (No. 6) oil or natural gas. Complete combustion of the fuel is obtained by maintaining an excess of preheated air rising from the chamber below. It is important to note that in the use of heavy fuel oil, the oil is not atomized in the conventional manner. Nor are we concerned with conventional flame propagation resulting from the mixing of fuel and air. Fuel burns in a fluid bed without visible flame, combustion being accomplished as a result of a turbulent, boiling mixture of air, fuel, and solids at an elevated temperature.

At calcination temperature of 1500°F or higher, immediate calcination of the fine carbonate feed takes place. Simultaneously, the sodium in the feed melts and causes the calcined fines to adhere to pellets already present in the bed. The space above the fluid bed, called the freeboard, is expanded in area to decrease the velocity of the uprising gases. This will allow fine solids to disengage from the gas stream and fall back into the fluid bed where they act as nuclei for pellet growth. If fine solids are not generated for pellet nuclei, a portion of calcined pellets is recycled through a roll crusher for reentry to the reactor.

Calcined lime pellets, which are $^1/_4$ in. diam. to 20 mesh in size, are allowed to flow through an internal underflow pipe at a rate which is automatically controlled to maintain a predetermined bed depth. Within the cooling compartment, the hot pellets are cooled and the incoming air is heated to a bed temperature of 300–400°F. Similarly the cooled pellets are allowed to flow from this chamber at a rate which keeps the depth of the cooling bed constant. The product pellets, conveyed to a product bin in a bucket elevator, are now ready for reuse in the causticizing system.

Total connected power for this plant is 425 hp. However, preliminary operating experience indicates this can be reduced somewhat. We fully expect total lime recovery in this plant to be in excess of 95%.

PLANT STARTUP SEQUENCE

Two types of startup procedures are used. One is for a cold, empty reactor, and the other for a full, hot reactor.

Cold startup of the lime-reburning plant involves preheating the calcination reactor, and a starting bed, to operating temperature. Concurrently, the drying system must also be started (as heat from the calciner becomes available) so that dry carbonate feed is available for the calcination reactor when operating temperature is attained.

With fluidizing air passing through the reactor, preheating is begun with the gas-fired preheat burner located in the freeboard section of the cooling compartment. When the air temperature in the calcining compartment approaches 600°F, a starting bed of calcined pellets (reactor product) is charged to the calcining compartment. Heating is continued with the preheat burner until a bed temperature of 1000°F is attained. At this time, the bed oil guns are inserted in the calcining compartment and heating is continued by direct oil injection. The preheat burner, having served its function, is now turned off. When natural gas is used as the main fuel, the preheat burner is used until a bed temperature of 1400°F is attained. Then the gas guns are inserted in the calcining compartment and heating is continued by direct bed gas burning. Preheating is concluded when the calcining bed is heated to calcination temperature. At this time, carbonate feed is started to the reactor and continuous operation of the reactor has commenced. Thereafter, calcining compartment temperature is controlled by the carbonate feed rate which is a function of the quantity of heat (or fuel) supplied to the reactor. When the volume (or bed level) of the calcining compartment reaches a predetermined level, transfer of calcined pellets to the cooling compartment is started. Similarly, when a predetermined level in the cooling compartment is attained, product removal from the reactor is started and maintained consistent with holding a constant cooling bed level.

The drying system of the plant is started when the drying system's temperature, measured in the cyclone, is 350°F and usually occurs during the midpoint of preheating the calciner

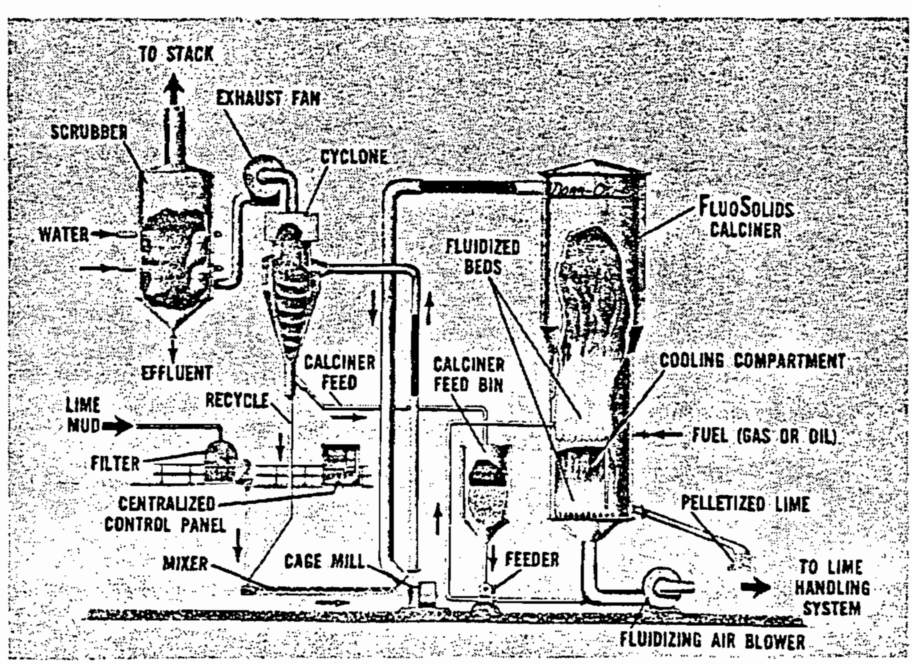

Fig. 1. Dorr-Oliver FluoSolids lime mud reburning system

bed. This is accomplished by activating the drum filter, paddle mixer, and cage mill; and feed to this system is begun by introducing a slurry feed to the filter. Adjustment of wet feed, recycled dry feed, quench air, and quench water is made to maintain the cage mill and cyclone dust collector operating temperature at about 275°F. Final adjustments of all process parameters are then made to obtain complete integration of the drying and calcining systems so that both systems act as one continuous operating unit.

This type of startup generally takes no longer than 6 hr.

The other startup procedure, namely, that of a full reactor and hot bed, is considerably faster and less complicated. This startup merely entails the starting of the exhaust fan, fluidizing blower, and cage mill. This action raises or fluidizes the beds and also puts the drying system under negative pressure. The fuel guns are then inserted and fuel burning is begun. While the bed is reheated to calcination temperature, the filter is started and precoated. When the drying system temperature reaches 300–325°F, the remainder of the drying system is activated by starting the paddle mixer. At a bed temperature of 1500°F, dry carbonate feed to the reactor is started and operation has commenced. Thereafter, minor process adjustments are made to the calcination and drying systems to obtain proper balance of the systems consistent with the desired production rate. This procedure takes a maximum of 30 min.

Shutting down a hot reactor with full beds is easier yet. This is done by first stopping the filter, the dry carbonate feed to the reactor, and the fuel flow to the reactor. When the filter cake has all dropped off, the paddle mixer and fluidizing blower are shut down. After 5–10 min, the exhaust fan, cage mill, and all other running equipment are deactivated, and shutdown is complete. The reason for the delay in shutting down the exhaust fan and cage mill is to insure complete dust removal from the duct work so that dust will not drop out and accumulate within the ducts. This procedure only takes 15 min.

This latter startup and shutdown procedure has proved to be an invaluable asset at S. D. Warren Co. Initially we were forced into these shutdowns because of minor equipment failures. Presently, however, we can plan advanced shutdowns for minor equipment modifications, or shutdown is forced upon us owing to the lack of lime mud. Whichever the case, very little time and effort are expended for these shutdowns. If required and if the overcapacity is present, the FluoSolids lime mud reburning plant can be economically operated two out of the three shifts per day. This type of operation is, in fact, currently being done on a small FluoSolids lime mud reburning unit at Gainesville, Fla., which reclaims spent lime from a water treatment facility.

INITIAL OPERATION

Plant operation commenced in mid-November, and following two false starts, a very successful 20-hr run was made during which an estimated quantity of 30 tons of reclaimed lime was produced. The reason for shutdown was lack of lime mud. For the next month or so, however, we ran into a series of "nuts and bolts" problems. These problems were mechanical in nature, and individually quite minor. Collectively, however, they proved to be quite frustrating and much downtime was logged for chute revisions, piping changes, and minor modifications to equipment. During this time, we estimated that a mere 25 tons of reclaimed lime was produced.

Ever since operations have resumed in the beginning of the year, the plant has been running up to its full expectations, and up to the present, very little lime mud has been pumped out to a reclaiming pond from the causticizing plant. Now that the operation is under good control, and data from this operation are reliable, two other problems have been noted.

The first problem was that of extremely poor filtration rates on the filter owing to blinding of the precoat media, which is lime mud. The blinding, of course, was due to excessive quantities of free lime (reported as $Ca(OH)_2$) in the lime mud feed to the filter. The free lime content consistently ran in the 7–12% range and originated in the causticizing plant. Because of the unique conditions under which this causticizing plant is being operated (at less than one-half rated capacity), it is necessary to have this free lime present to facilitate acceptable operation in a section of the causticizing plant. However once this problem was recognized, a secondary causticizing step was instituted in the causticizing plant by introducing a controlled quantity of green liquor to the semifinal white liquor clarification stage. This uses up the excess lime. This type of operation is not uncommon in European and a few U.S.A. causticizing plants. Ever since this change, poor filtration rate has not been a problem. Every effort is currently being made to keep the free lime content below 1%, which is necessary for maximum filtration rates.

The other problem, which was discovered only recently, is that of poor cyclone collection efficiency in the system. The solids entrained in the cyclone gas discharge are recycled back to the drying system. Thus the drying systems must process more solids than the calcination section of the plant at a given product capacity. Since the drying system's capacity is directly related to the heat available from the calcining section (through combustion gases and dust carry-over) this unbalanced condition results in a deficiency of heat available from the calcining section to dry all the solids processed in the drying system. To compensate for this heat deficiency, we are forced to run the calcination section at higher excess air than that required for complete combustion of the fuel. In other words we expend fuel just to heat excess air to make sufficient heat available to dry the solids in the drying system. However, as will be shown, very good product fuel requirement values were obtained in spite of this temporary problem condition.

PRELIMINARY OPERATING DATA

The test data include a period of 20 hr (total length of this run). Reason for shutdown was lack of lime mud from the causticizing plant.

The process flows were metered as follows. Incoming lime mud to the filter was metered by a magnetic flow meter. Solids concentration of the slurry was fixed, measured, and controlled by a radiation cell type density meter. The fuel oil flow to the calciner was metered through a totalizing oil flow meter in which the calibration was checked before the test. The product quantity was obtained by discharging the product on a continuous weighing belt totalizer also calibrated before the test run.

The data are shown in Table I. The overall product rate for the 20-hr test run was 32.7 tons/day with a heavy fuel oil consumption (corrected to 60°F gal) of 1821 gal/day. Calcination temperature was 1500°F and product discharge temperature was 300°F. These conditions result in a fuel heating requirement of 8.1 million Btu/ton of product. Of prime significance is the fact that this low product heating value was obtained with 60% excess air. Excess air is defined as the amount of air over and above that required for complete combustion of the fuel oil burned in the reactor. If the excess air in this test run were reduced to 20%, which is normal for FluoSolids fuel-burning systems, the product heating value could have been as low as 7.2 million Btu/ton of product.

There were two reasons for running this test at high excess air. First was the poor cyclone collection efficiency

Table I. Operating Data 20-Hr Test

Calcination temp., °F	1500
Product discharge temp., °F	300
Product rate, tons/day	32.7
Heavy fuel oil rate corrected to 60°F, gal/day	1821
Fluidizing air rate,[a] std. ft³/min	3020
Product heating value,[b] Btu/ton product	8.1×10^6

[a] Excess air for test run was 60%.
[b] Low heat value of oil is 145,000 Btu/gal (as per Marathon Oil Co., Muskegon, Mich.).

Table II. Chemical Analysis of Material

Sample source	Total CaO	Available CaO	CO_2	Total MgO
Filter cake	53.8	0.15	...	0.89
Cyclone discharge	55.3	4.53	38.9	0.93
Calcined product	93.5	90.6	0.40	1.41

that imposed a heavier than normal load through the drying system. Second, the FluoSolids reactor as it now stands was designed for a 45-ton/day production rate. Although lower carbonate feed rates and correspondingly lower fuel rates are possible, fluidizing air (which is also fuel combustion air) cannot be decreased or the bed will defluidize. Thus excess air is present and fuel is expended in heating this air to calcination temperature. Current mill production reaches the lime mud equivalent of less than 45 tons/day CaO. In order to obtain longer continuous operating times on the calciner, to check long-term equipment reliability, capacity is purposely reduced at the expense of higher fuel consumption. Later, if lime-mud availability is still less than 45 tons/day equivalent CaO, it is planned to run the calciner intermittently, but at design capacity, to obtain the full economic advantage of this system. This type of operation is fully practicable because of the startup and shutdown ease of a hot reactor.

The success of this process depends on obtaining proper agglomerating or pelletizing conditions. If too little agglomerating agent is present the cementing of dust to pellets within the bed will be considerably reduced and the dust will be elutriated from the bed. Very little, if any, pelletized product will be formed. If the proportion of agglomerating agent present is too great, cementing action of the dust to existing pellets in the bed will cause the larger pellets to cement with each other, resulting in defluidization, or in general, uncontrolled pelletization. In paper mill lime mud reburning, the prime constituent in the agglomerating agent is soda ash which is already present in the lime mud from the causticizing plant. At S. D. Warren Co., proper pelletizing conditions are achieved by controlling the soda ash content of the lime mud filter cake.

PRODUCT QUALITY

Chemical analysis of material at various points in the FluoSolids lime mud reburning plant are shown in Table II. As is shown, available CaO in the calcined product is 90.6%. Furthermore, the low weight loss of 0.4% due to CO_2 evolution indicates essentially complete burning of the available $CaCO_3$. Also, some available MgO is present in the product.

It is important to note that the conversion of this sludge to quicklime is accomplished at a temperature of 1500°F in the FluoSolids reactor. This is possible by the introduction of fine carbonate into a hot bed section that has very little CO_2 present. In addition, the extremely small distance from the particle center (from which the CO_2 must be driven during the dissociation of $CaCO_3$) accounts for the low operational temperature.

Because of the consistent high purity of FluoSolids reburned lime, it is theoretically possible to obtain much better chemical efficiency and control in the causticizing plant. We found that such was not the case when we used purchased rotary kiln lime. In addition, when using FluoSolids reburned lime in the causticizing plant, we found a very substantial decrease in inert rejects from the slaking step.

Physically, the product is a very desirable pellet ranging from −8 to +35 mesh in size with a bulk density of about 70–75 lb/cu ft. A photograph of typical pellets produced in the FluoSolids reburning unit at S. D. Warren Co. is shown in Fig. 2.

FURTHER DEVELOPMENT

The effect of FluoSolids reburned lime mud in a causticizing operation

Fig. 2. Typical pellets from FluoSolids reburning unit

will be presented at a later date. We feel that it would be premature at this time to elaborate on this system since (1) operation of this plant on FluoSolids lime has been very limited, and (2) because of the unique operation of the plant at this time, namely at less than one-half design capacity, data will not be as meaningful.

Another Dorr-Oliver FluoSolids lime mud reburning plant for a pulp and paper mill is currently being erected on the West Coast and will have a rated capacity of 50 tons/day of reclaimed lime. In this plant lime mud reburning and limestone burning will be carried out simultaneously.

The use of a Dorr-Oliver FluoSolids lime mud reburning system promises vastly improved processing and economy to the kraft mill operator. The dense, dust-free, granular, high-quality product obtained on the initial operation of S. D. Warren Co.'s Central Mill at an average product heating value of 8.1 million Btu/ton is now fact. The full economic potential of such a system, which suggests the possibilities of sustained ratios of 7.5 million Btu/ton and even lower, is being pursued.

The startup and shutdown ease of this plant, which makes it entirely practical and economical to operate the plant intermittently, is ideally suited for long-term plant expansion programs. With overcapacity the plant can be operated intermittently and later, at full capacity, run continuously. The economical operation of this plant at low capacities also suggests economical reburning for small kraft mill operations.

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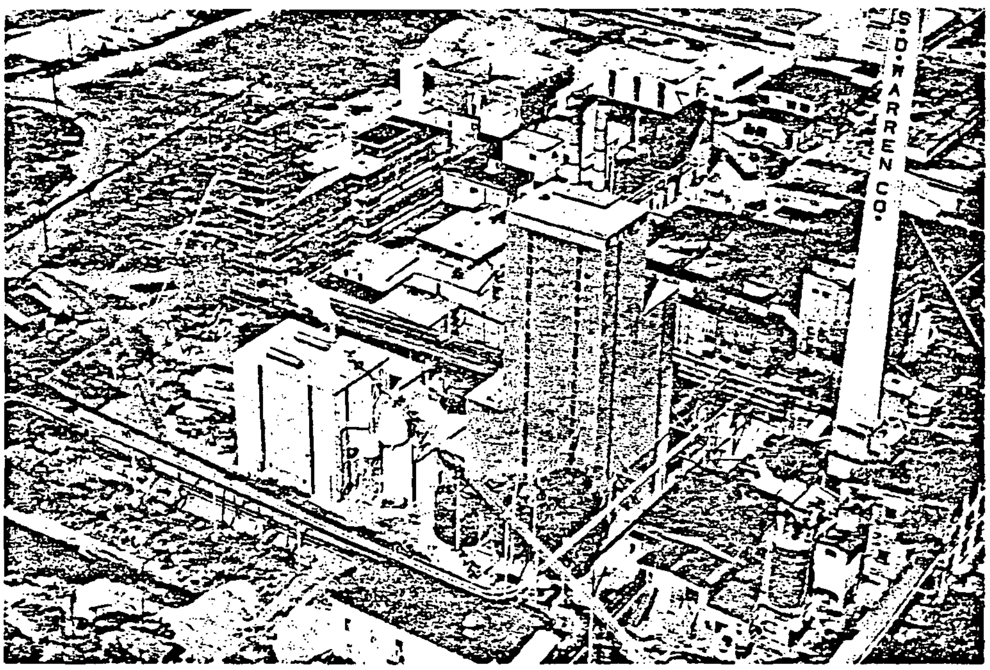
E-9

Operating Parameters of Fluidized Bed Lime Mud Reburning System

JOHN S. MORAN and CLARENCE J. WALL



The Central Mill of S. D. Warren Co. White building in center houses the entire causticizing system including the FluoSolids Lime Mud Reburning System.

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The decision by S. D. Warren Company to install a 70 t.p.d. Dorr-Oliver lime mud recovery unit was based on the following reasons:

1. The compactness of the FluoSolids plant allowed for the installation of lime recovery equipment early in the two year expansion program. The installation would occupy only 2775 square feet of floor space (44 feet wide by 63 feet long). Construction of a rotary kiln would not have been possible until near the end of the building period due to layout difficulties which would have existed because the old pulp mill was to be kept in operation during construction.

2. Since the FluoSolids plant was able to be placed adjoining the causticizing plant, the installed cost was lower than for a rotary kiln.

3. The flexibility of the fluidized bed process allowed for maintaining varying production schedules during the startup of the new pulp mill because of the ease of shutdown, startup, and rate changes.

4. The fuel costs promised to be low.

5. The product was desirable, being clean, easy to handle and of high quality with few unburned centers.

6. Refractory maintenance was shown to be low.

7. The efficient recovery system gave very low air pollution.

8. The fluidized bed process had low manpower requirements.

Operating Parameters of Fluidized Bed Lime Mud Reburning System

JOHN S. MORAN and CLARENCE J. WALL

A fluidized bed reactor for reburning lime mud has been in operation for the past 2 1/2 years. The calcining system produces a dense, free flowing, dust free, pelletized lime product of 87% available CaO. The average fuel consumption with 30% or more excess air is 7.2 million Btu per ton of product under current operating conditions at 70–93% of design capacity. Detailed operating conditions and process data are presented.

Keywords: Fluidized bed furnaces Fluidizing Recovery White liquor mud Fluidized bed roasting Roasting Roasters Cyclone dust collectors Solids size Heat balance Chemical analyses

THE fluidized bed process for recovery of kraft pulp mill carbonate sludge has been in operation at S. D. Warren Co. in Muskegon, Mich., since Nov. 1963.[1] General principles of fluidization have been described by Brandt, Krause, and Shafer.[2]

This paper presents the operating data for the FluoSolids[3] plant.

FLOWSHEET

A flowsheet of the system installed at Muskegon, Mich., is shown in Fig. 1.

The lime mud reburning system is divided into two basic parts; the drying system in which lime mud filter cake is dried, and the calcining system which produces dense pellets of calcined lime.

The operation of the drying system is as follows: Washed lime mud from the causticizing system is pumped to a lime mud storage tank. (A flowsheet of the filter feed system is shown in Fig. 2.) Slurry circulates through a loop held at constant pressure by a manual valve. Constant solids concentration is maintained by a radiation density cell which automatically adds water to the loop as required. Lime mud is metered from this circulating loop to the filter through a magnetic flow meter and an automatic control valve. By maintaining a constant solids concentration and a constant pressure in this circulating loop, accurate and reliable metering of mud is obtained. With this arrangement, the filter necessarily operates at variable submergence. At low capacity, vat level is minimal. At increased capacity, vat level or drum submergence increases and filter output automatically follows input. With constant input and with blinding of the precoat, drum submergence increases to maintain constant output. As the vat level nears the weir overflow level it is time to change precoats. Hot water wash is applied to the cake via five spray headers as required for final control of alkali content of the lime mud.

Referring to Fig. 1, a screw conveyor transports filter cake to the paddle mixer where it is mixed with dry recycle calcium carbonate from the primary cyclone, along with a small amount of water as required for control of drying system temperature. Rate of dry solids recycle to the paddle mixer is adjusted by the splitter valve to maintain about 10–15% moisture in the mixer discharge stream. This mixture enters the cage mill along with precooled calciner gases, where the moist solids are dried and disintegrated to a fine powder. The gases sweep the fine dry solids out of the cage mill to the two stage dry dust cyclone collectors.

The dry calcium carbonate feed flows by gravity to a surge bin. This bin is equipped with level indicators to enable the operator to control demand and supply by adjusting input to the calciner or input to the filter to maintain a solids balance between the two systems. Gases from the secondary cyclones pass through a scrubber before they are emitted to the atmosphere. Fresh water is added to the inlet of the wet gas exhaust fan which is an integral part of the scrubber. Scrubber discharge water is recycled to the lower humidifying–primary scrubbing stage and to the upper eliminator stage. Scrubber effluent is pumped to the final stage of the white mud washer for recovery of contained solids and to serve as a portion of the hot water for mud washing.

The calcination reactor has been described previously.[1]

OPERATING DATA

Drying System

The two stage dust collecting system captures 87–92% of the carbonate feed solids, with the balance of the solids going to the scrubber for collection and return to the drying system. The circulating load of dry solids is maintained at a ratio of about 4 to 1, and the indicated collection efficiency of the two stage dust collectors is 98%. With this cyclone operation the drying system operates efficiently, and an overall fuel requirement of 6.9–7.4 million Btu per ton of product is being obtained.

Data on solids capture of the cyclone dust collectors is presented in Table I. The data were obtained as follows. The feed input to the system was measured by a recording flowmeter. Amount of solids present in the filtrate from the filter was determined by collecting samples and determining solids content. The filtrate rate was calculated based on a water balance around the filter as illustrated in Table I. Solids passing the cyclone dust collectors were determined by measuring the scrubber effluent rate and solids concentration in the effluent.

Typical size analyses of the carbonate solids is shown in Table II. Although the calcium carbonate feed solids are fine in size, excellent cyclone collection efficiency is indicated by the 41% of -10 to $+5$ μ solids in the secondary cyclone product and by the presence of only 7% of $+10$ μ solids in the scrubber effluent stream.

The wet gas scrubber efficiently cleans the exit gases. Scrubber collection efficiency data, taken in accordance with the IGCI test code, for this unit is pre-

[1] Hotz, H. J., Sr., Hinkley, P., and Erdman, A., Jr., *Tappi* 47 (11): 174A (1964).
[2] Brandt, M. W., Krause, F., and Shafer, M., *Tappi* 47 (5): 137A (1964).
[3] Registered trademark identifying Dorr-Oliver fluidized bed processing equipment.

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sented in Table III, indicating a loading of 0.0068 grains per actual cubic foot of exit gas. Collection efficiency at this minimal grain loading is 99.9%+, and at current production rates, solids emission from the plant stack amounts to only 0.9 lb/hr or 21.6 lb/day. Also, there has been no visible evidence of any alkali fumes being emitted from the stack as is often the case with rotary kiln reburners.

Calcining System

Production and fuel requirement data is presented in Table IV. This information was obtained from the daily log sheets, where the operator records data hourly, and from the instrument charts. The no. 6 oil has a net (or low) heating value of 144,900 Btu/gal (60°F). The production rate is based on the carbonate feed solids to the filter and takes into account carbonate solids that pass the dry cyclone dust collectors as was discussed earlier in Table I.

Table V gives chemical analyses of the calcium carbonate feed, intermediate materials in the drying system, and

Table I. Cyclone Dust Collectors Capture Data

	Avg. (56 tests)	Range
Filter		
Feed		
gpm	23.2	19–32
Specific gravity	1.39	1.32–1.43
% Solids	44.9	40.8–49.6
Cake, % solids	66.5	62.2–70.4
Filtrate—solids ppm	78	17–360
Scrubber effluent		
Rate, gpm	55.8	38–68
Specific gravity	1.024	1.015–1.040
% Solids	2.5	0.6–4.49
Cyclone dust collectors		
Solids capture,ᵃ %	90.7	83.2–96.7
Calc. collection efficiency, %	98.0	97.1–99.6

ᵃ Solids capture determined as illustrated by following example.

Feed to filter: 21.25 gpm, 1.41 spec. gr., 45.8% solids
Gross solids input = 21.25 × 8.345 × 1.41 × 0.458 = 114.5 ppm
Gross water input = 21.25 × 8.345 × 1.41 × 0.542 = 135.5 ppm

Filter cake: 68.5% solids
Water in filter cake = (114.5/0.685) × 0.315 = 52.5 ppm
Filtrate rate = 135.5 − 52.5 = 83 ppm
Solids in filtrate (19 ppm) = 83 × 0.0019 = 0.16 ppm
Net solids to drying system = 114.5 − 0.16 = 114.34 ppm

Scrubber effluent: 44.8 gpm, 1.013 spec. gr., 2.84% solids
Solids effluent = 44.8 × 8.345 × 1.013 × 0.0284 = 10.78 ppm

Solids capture =

$$\frac{114.34 - 10.78}{114.34} \times 100 = 90.5\%$$

Table II. Carbonate Solids Size Analyses

Solids size	Filter feed	Paddle mixer discharge (feed to cyclones)	Primary cyclone	Secondary cyclone	Scrubber effluent solids
Larger than 30 μ, %ᵃ	3	5	9	0	0
Larger than 20 μ, %ᵃ	10	12	19	5	0
Larger than 10 μ, %ᵃ	42	44	53	38	7
Larger than 5 μ, %ᵃ	77	76	81	79	52

ᵃ Cumulative.

Table III. Scrubber Collection Efficiency Data

	Run 1	Run 2	Average
Scrubber exhaust			
Date	3/30/65	3/31/65	
Time	3:30 p.m.	3:00 p.m.	
Length of run, min	90	90	
Sample			
Volume, actual cu. ft	250	250	
Weight, g	0.120	0.120	
Loading, grains/actual cu. ft	0.0074	0.0062	0.0068
Scrubber inlet temp., °F			
Dry bulb	300	300	
Wet bulb	148	148	
Scrubber outlet temp. (saturated), °F	146	146	
Scrubber exit gas volume, cfm	...	...	15,600
Solids in exit gas, lb/hr	...	...	0.90
Scrubber Effluent			
3/30/65, 3:30 p.m.			
54 gpm, 1.035 spec. gr., 3.99% solids			
lb solids/hr = 54 × 8.345 × 1.035 × 0.0399 × 60 =	1116		
3/31/65, 3:00 p.m.			
54.8 gpm, 1.02 spec. gr., 4.49% solids			
lb solids/hr = 54.8 × 8.345 × 1.02 × 0.0449 × 60 =		1260	
Average		...	1188
Scrubber collection efficiency			
$\frac{1188}{1188 + 0.90} \times 100 = 99.9\%+$			

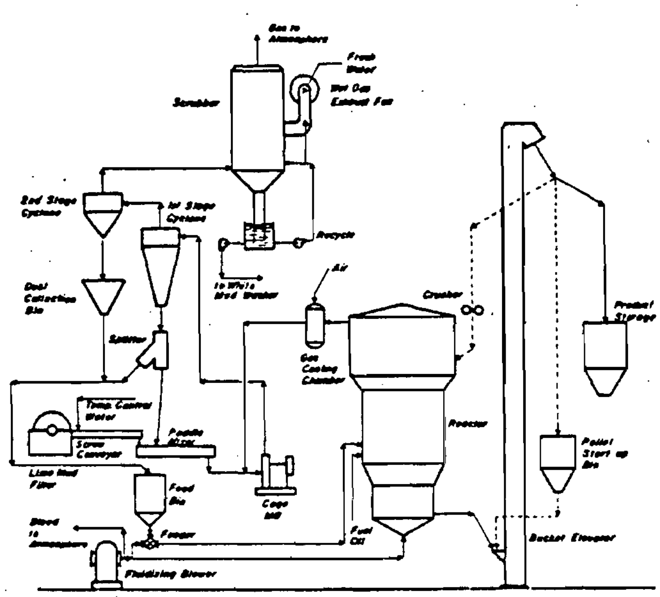


Fig. 1. Process flowsheet

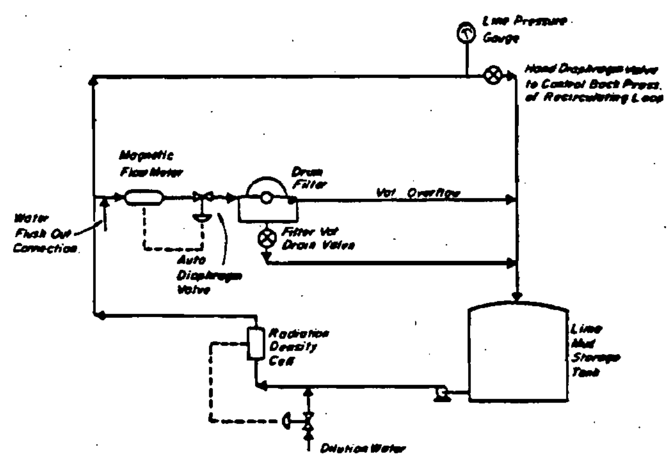


Fig. 2. Filter feed flowsheet

Table IV. Production Rates and Heat Requirements—1965 (No. 6 Oil)

	Feb. 8	Feb. 15	March 26	March 30
Daily Figures				
Length of test, hr	24	24	8	24
Total airflow, std. cfm	3875	3825	3835	3735
Total oil used, gal	2790	2810	1047	2775
Oil rate, gpm	1.94	1.95	2.18	1.93
% Theoretical air	132	133	119	131
Production rate, tons/day	53.6	56.9	65.0	56.5
Heat required, millions Btu/ton	7.5	7.15	7.0	7.1

	January	February	March	April
Monthly Figures				
Tons produced	1080	1250	1266	1275
Heat requirement, millions Btu/ton	7.96	7.45	7.4	6.9
Total operating time, days	25.3	23.8	22.5	21.0
Production rate, tons/day	42.6	52.5	56.3	61.0

reburned lime product. With a carbonate feed solids of 53.5% total CaO and 42.4% loss on ignition, the reburned lime contains 87.1% available CaO (available CaO by the sugar method). The low loss on ignition and residual CO_2 in the lime indicates essentially complete burning of the carbonates. These low figures are rather startling considering the relatively low 1600°F calcining temperature.

Because of the very close control of the calcination temperature the reburned lime is of very consistent quality. It has been possible to obtain better chemical efficiency and control in the causticizing plant because of this consistent lime quality. Also, with Fluo-Solids lime only about one wheelbarrow per day (approximately 100 lb) of rejects or grits are produced in the slaker.

Physically the product is a very desirable pellet material, ranging in size from −4 mesh to +65 mesh and with a bulk density of about 70–75 lb/ft³. A photograph of typical pellets produced in this reburning unit has been published previously.[1] This pellet product is free flowing, has a consistent low angle of repose, and is dust free. These qualities plus the relatively low discharge temperature of 400–600°F from the calciner eliminates many dust problems.

In order to maintain proper fluidization it is necessary to control pellet size. Both maximum pellet size and size distribution must be considered. Oversize pellets (more than 15% +6 mesh) and pellets all of the same size can lead to poor fluidization. Alkali content of the carbonate feed has an important bearing on the pellet size and rate of pellet growth. Also, there may be trace quantities of other elements that may influence pelletization, and this should be investigated. On occasions the pelletization has been self-seeding for periods of up to 4 days. Normally, it has been found necessary to artificially reseed the pelletization mechanism up to 25% of the time. This is done by diverting a portion of the product through crushing rolls and returning them to the calcining compartment. For maximum reseeding effect the pellets are crushed to about 50% −20 mesh and with a minimum of −65 mesh fines. Overgrinding is avoided because this produces too much fine dust which is not retained in the reactor. Insufficient crushing gives a minimum of particles to act as new nuclei. Figures 3 and 4 illustrate graphically the effect of reseeding on the size distribution of the lime pellets. Without reseeding, the pellets grow in size; with reseeding, pellet size decreases. Referring to Fig. 3, the product contains no +6 mesh pellets with a filter cake solids feed containing 0.37% Na_2O. With 0.51% Na_2O in the feed (Fig. 4), the product contains 4–16% of +6 mesh pellets, indicating that higher alkali content in the feed tends to increase pellet growth rate and pellet size. To maintain proper pellet size and size distribution, reseeding is started when the amount of +20 mesh in the product reaches 90% and stopped when the amount of +20 mesh in the product drops below 80%. A sample of pellets is drawn directly from the calcining bed every 2 hr and analyzed on 6, 8, 10, 14, and 20 mesh screens for control purposes.

Operating conditions and heat balance data for typical current operation is presented in Table VI. As the capacity of the unit is increased to the 70 ton/day design rate or above, it is anticipated that the heat requirement will be even lower. Temperature charts for calciner show calciner freeboard temperatures 55–70°F below the fluid bed temperature. This is a positive indication of complete oil burning in the fluid bed. Accordingly, the capacity of the unit can be increased by increasing the fuel rate and the carbonate solids feed rate with no increase in the air to the reactor. This can be done up to the point where the calciner freeboard temperature equals the calciner fluid bed temperature. If pushed beyond this point, freeboard burning of a portion of the fuel is to be expected. This, of course, is to be avoided, as heat release in the freeboard is not effectively utilized. With no. 6 fuel, freeboard burning has not been experienced. On one day, the plant was operated at a capacity of 65 tons/day for an 8 hr period. During this period, per cent theoretical air was 119% and the fuel requirement 7 million Btu per ton of product. Reactor temperature charts showed the calciner freeboard temperature 20–30°F below the bed temperature. This approaches optimum oil-air ratio for most efficient fuel

Table V. Chemical Analysis of Calcium Carbonate Feed and Reburned Lime
(% by weight, dry basis)

Material	Total CaO	Avail. CaO	Loss on ignition at 1000°C	CO_2	Total CO_2	MgO	Total sulphur	Acid insol.	R_2O_3
Filter feed solids	53.7	0.7	42.0	...	0.8	1.4	0.2	0.1	1.4
Filter cake solids	53.5	0.4	42.4	...	0.6	1.0	0.3	0.2	
Pug mill discharge (feed to cyclones)	54.1	2.2	41.5	...	0.7	...	...	0.1	
Primary cyclone discharge (feed to reactor)	54.4	4.1	41.4	...	0.7	1.0	0.2	0.2	1.4
Secondary cyclone discharge (feed to reactor)	54.5	2.1	41.5	...	0.7	0.8	0.2	0.2	2.5
Scrubber effluent solids	53.7	0.8	41.8	...	0.4	0.6	0.1	0.1	1.7
Reburned lime	91.5	87.1	0.6	0.2	1.0	1.8	0.8	0.3	3.1

burning and minimal heat requirements.

Table VII summarizes dust carryover for the reactor, taken in accordance with the American Society of Mechanical Engineers Power Test Code no. 21. Dust carryover from the calcining compartment amounted to 14.1% while reseeding, and 12% with no reseeding. The dust samples were taken from the lower portion of the vertical hot gas duct between the reactor and the cage mill. The gas velocity in the calciner freeboard was approximately 95% of full capacity design space velocity while reseeding, and about 80% with no reseeding. Based on this data it is to be expected that dust carryover from the calciner will not exceed about 15% at full design (70 tons/day) capacity. The dust carryover that is being obtained is much lower than was anticipated. The amount of carryover from the reactor has a considerable influence on the heat requirement for the calciner, because carryover dust recarbonates and rehydrates in the drying system.

As will be noted by the size analyses of the carryover dust (Table VII) this dust material contains a considerable amount of +65 mesh material. The coarse material is lime pellets which are blown out of the reactor because of high velocity jetting in the fluid bed. This is typical for a material such as these lime pellets which have a narrow size range and for operation with a 7–8 ft fluid bed depth at a space velocity of 5–6 ft/sec. This jetting-over of +65 mesh pellets is due in part to the bed section of the calcining compartment being bricked into 8 ft ID. This was required for initial operation at 50–60% of design capacity. With this bed brick lining still in place the bed space velocity at current operating conditions and capacity is about 15% above the design rate. It is possible that by removing this additional bed lining to give a 10 ft ID fluid bed section, a decreased jetting-over of course lime pellets can be expected. This possibility is being deferred until the optimum lime requirement for the mill has been established. If it is found that current operating capacity in the

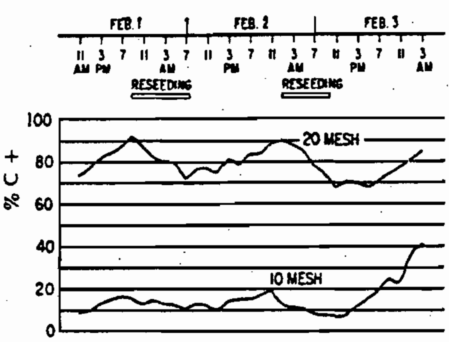


Fig. 3. Pellet product size control. Production rate 44 tons/day, 0.37% Na_2O in filter cake solids. % C + = % cumulative plus

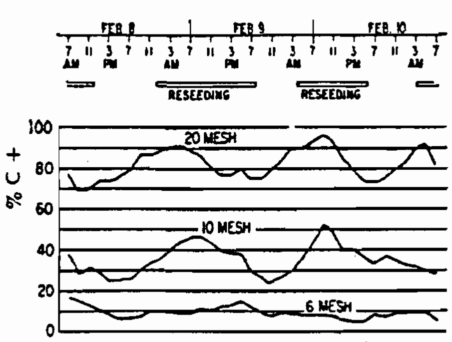


Fig. 4. Pellet product size control. Production rate 55 tons/day, 0.51% Na_2O in filter cake solids. % C + = % cumulative plus

Table VI. Operating Conditions and Heat Balance

Operating Conditions

Total airflow to reactor, std. cfm.	3735
Airflow to cooling bed, std. cfm	3500
Length of test period, hr	24
Oil used, gal (60°F)	2775
Oil rate, gpm	1.928
% Theoretical air	131
Calcining bed temperature, °F	1600
Calcining freeboard temperature, °F	1530
Cooling bed temperature, °F	517
Dust carryover from reactor, %	12
Crushed pellet reseeding rate, tons seed per ton product	0.314
Production rate, tons/day	56.5
Carbonate feed analysis, % by weight (dry basis)	
$Ca(OH)_2$	5.1
$CaCO_3$	90.5
$MgCO_3$	1.6
Inerts	2.1
Na_2O	0.7
Reburned lime analysis, % by weight	
Available CaO	84.5
Loss on ignition at 1000°C	0.15
CO_2	0.28
Na_2O	1.18
MgO	1.17
Inerts	3.85
Reactor exit gas analysis (by orsat), % by volume (dry)	
CO_2	18.5
O_2	8.0

Heat Balance Summary (Basis 1 ton Product)

		Btu per ton product	% of total
A. Heat in			
1. 95,000 std. cu. ft air at 110°F		78,500	1.1
2. 49 gal no. 6 oil at 144,900 Btu/gal		7,100,000	98.9
Total		7,178,500	100.0
B. Heat out			
1. Sensible heat in combustion gases 98,784 std. cu ft at 1530°F		3,015,000	42.0
2. Heats of reaction, Btu/lb			
197 lb $Ca(OH)_2$ at 635 =	125,000		
3,490 lb $CaCO_3$ at 765 =	2,670,000		
61.8 lb $MgCO_3$ at 600 =	37,000		
	2,832,000	2,832,000	39.4
3. Sensible heat in CO_2 and H_2O from feed calcination			
1567 lb CO_2 at 1530°F =	602,000		
48 lb H_2O at 1530°F =	35,300		
	637,300	637,300	8.9
4. Sensible heat in lime product			
1690 lb CaO at 517°F =	148,000		
310 lb inerts at 517°F =	29,800		
	177,800	177,800	2.5
5. Sensible heat in dust carryover			
231 lb CaO at 1530°F =	71,200		
43 lb inerts at 1530°F =	1,640		
	72,840	72,840	1.0
6. Heating crushed pellet seed from 300 to 517°F			
530 lb CaO 300 to 517°F =	23,400		
98 lb inerts 300 to 517°F =	6,450		
	29,850	29,850	0.4
7. Radiation (by difference)		413,710	5.8
Total		7,178,500	100.0

range of 50–60 tons/day is the optimum rate then premature removal [illegible]e present bed lining to give a 10 ft I[illegible]d section would require more air for fluidization of the pellets than is required for efficient fuel combustion, resulting in high fuel requirements.

For future units consideration should be given to increasing the size, diameter and height, of the calcining freeboard to decrease the jetting-over of coarse material from the fluid bed. This would decrease the fuel or heat requirements and should decrease the amount of artificial seeding (return of crushed pellets) as these fine pellets, if retained in the reactor, would serve as seed.

Lime makeup for the FluoSolids—recausticizing system varied quite widely during the first year of operation. This occurred while the various unit operations of the new pulp mill were being put on stream and the old units shut down. With the new pulp mill in normal operation, lime makeup has been running about 6%.

The use of natural gas for firing the calciner has been tested and found to be equally as good as no. 6 oil. Like oil, the natural gas is introduced into the calcining fluid bed through fuel guns located around the periphery of the reactor. With oil, 12 fuel guns are used. With gas, 24 fuel guns are used. Three different lengths of gas guns are used, and the gas guns are inserted into the bed at two different levels near the bottom of the fluid bed. This arrangement was found necessary to give proper distribution of natural gas into the fluid bed. Efficient gas burning is obtained at 1600°F fluid bed temperature with 25–30% excess air. Below 25% excess air, some freeboard burning of the gas is encountered. Results of a series of natural gas firing tests are presented in Table VIII. As shown, operation with natural gas is equal to operation with oil. This could result in a lower fuel cost for operation with natural gas because of the possible lower cost of gas. For kraft mill operation in general, this means a choice of fuel with an alternate fuel as standby if desired.

Total connected power for the calcining plant, starting with the paddle mixer and ending with the product elevator, is 465 hp. At current operating capacity of 55–60 tons/day the motors are operating at about 85% of full load. On this basis, power requirements are 125 kw-hr/ton of reburned lime.

Based on operation of a lime mud reburning unit at a municipal water treatment plant it was anticipated that precooling of the reactor exit gases would be necessary to prevent hard scale formation in the hot gas duct between the reactor and the cage mill and in the cage mill. This system has operated with no precooling, other than heat loss by radiation, at cage mill inlet gas temperatures up to 1500°F with little evidenc[illegible] of scale buildup in the hot gas duct or [illegible] the cage mill.

It was anticipated that periodic shutdown of the reactor would be required to remove scale that might form in the calcining compartment. Experience to date indicates that operation for periods of 6 months or longer without having to descale the reactor is to be expected. During the first 1½ years of operation

Table VII. Measurement of Dust Carryover from Fluosolids Reactor

	Run 3[a]	*Run 4*[a]	*Average*	*Run 5*
Location	Exit duct	Exit duct	...	Exit duct
Date	3/31/65	3/31/65	...	3/31/65
Time	9:50–10:50 a.m.	11:10 a.m.–12:10 p.m.	...	3:09–4:09 p.m.
Length of test, min	60	60	...	60
Sample				
Volume actual cu. ft	176	176	...	161.8
Weight, g	41.582	45.312	...	38.661
Dust loading, grains per actual cu. ft	3.66	3.98	3.82	3.69
Gas volume at dust sampling point, actual cfm at temp. and pressure	20,800	20,800	20,800	18,250
Carryover dust rate				
lb/min	...	...	11.35	9.62
tons/day	...	...	8.18	6.94
Dust analysis, % loss on ignition at 1000°C	...	...	8.9	10.3
Carryover dust rate, corrected for 0% loss on ignition, tons/day	...	...	7.45	6.22
Reactor production rate, tons/day	...	...	45.35	45.35
% Dust carryover[b]	...	...	14.1	12.0

[a] Reactor being reseeded at a rate of 1.25 tons/hr of crushed pellets during runs 3 and 4, and with no reseeding during run 5.

[b] % Dust carryover =

$$\frac{\text{carryover dust rate corrected to 0\% on ignition}}{\text{Reactor production rate + carryover dust rate corrected to 0\% loss on ignition}} \times 100$$

Size Analyses of Lime Product, Crushed Seed, Carryover Dust on 3/31/65
(*% cumulative plus*)

Tyler mesh	*Lime product while reseeding*	*Lime product, no reseeding*	*Crushed seed*	*Carryover dust while reseeding*	*Carryover dust, no reseeding*
8	10.5	9.6	2.1		1.1
10	38.8	39.8	11.2	8.2	6.8
14	68.6	67.6	28.4		11.8
20	86.7	85.0	51.0	18.0	14.8
28	95.2	93.6	72.4		16.3
35	98.5	97.6	84.4	21.0	18.3
48	99.5	99.4	90.1		19.0
65	100.0	100.0	93.5	25.5	21.6
100			95.9		25.9
150	...	...	97.2	...	32.1
200				45.8	36.9
Microns					
30				47.5	51.5
20				52.5	57.0
10				62.0	70.0
5				72.0	84.0

Table VIII. Natural Gas[a] Firing Data—1965

	April 30	*May 1*	*May 2*	*April 30 to May 6*
Length of test, hr	20	20	20	164
Total airflow, std. cfm	3825	3725	3615	
Natural gas flow, std. cfm	296	305	297	
% Theoretical air	135	128.5	128	
Production Rate, tons/day	56.2	55.5	56.5	58
Tons product				398
Total natural gas used, std. cu. ft				3,011,000
Fuel requirement, millions Btu/ton	6.95	7.2	6.92	6.9

[a] Natural gas specifications:

Analysis	*Dry, %*
N_2	6.93
CO_2	0.26
He	0.11
CH_4	84.92
C_2H_6	5.96
CH_3	1.61

Butane, pentane, hexane 0.21
Stoichiometric air: 9.52 cu. ft air/cu. ft natural gas.
Net (low) heating value: 912 Btu/std. cu. ft.

the plant was shut down four times. In all four cases the shutdown was not specifically for reactor descaling but for either inspection, development modifications, or maintenance, and the reactor was descaled at that time.

During initial operation of the system, a hard scale buildup on the leading edge of the fan wheel of the wet gas scrubber was encountered. Scale would build up to a thickness of $^1/_4$ in. and then fly off, causing unbalance of the fan wheel. Rearrangement of the original fresh water sprays plus the addition of four jet sprays coupled with an adequate fresh water supply now provides complete coverage of the fan wheel. A slight modification to the fan wheel aids spray distribution. A screen was installed in the scrubber effluent recycle system to stop shower plugging. With these changes, scale buildup in the fan wheel has been greatly reduced. A thin scale, the thickness of writing paper, accumulates on the fan blades over a 2–4 week period. Periodic cleaning of the fan wheel and routine inspection and cleaning of the recycle sprays is all that is required to maintain proper operation of the wet gas scrubber. Other arrangements employing a hot gas fan, followed by a scrubber, can be considered. However, whatever the system, routine maintenance is to be expected.

PROCESS CONTROL

For proper and efficient operation, calcination temperature, drying system temperature, and fluid bed levels are accurately controlled.

The calcination temperature is maintained at 1600 ± 10°F by a temperature recording controller. The airflow is set for a given capacity and the fuel rate manually adjusted to optimum fuel-air ratio for efficient fuel combustion. The temperature controller automatically adjusts the carbonate feed rate to maintain calcination temperature at the desired preset level.

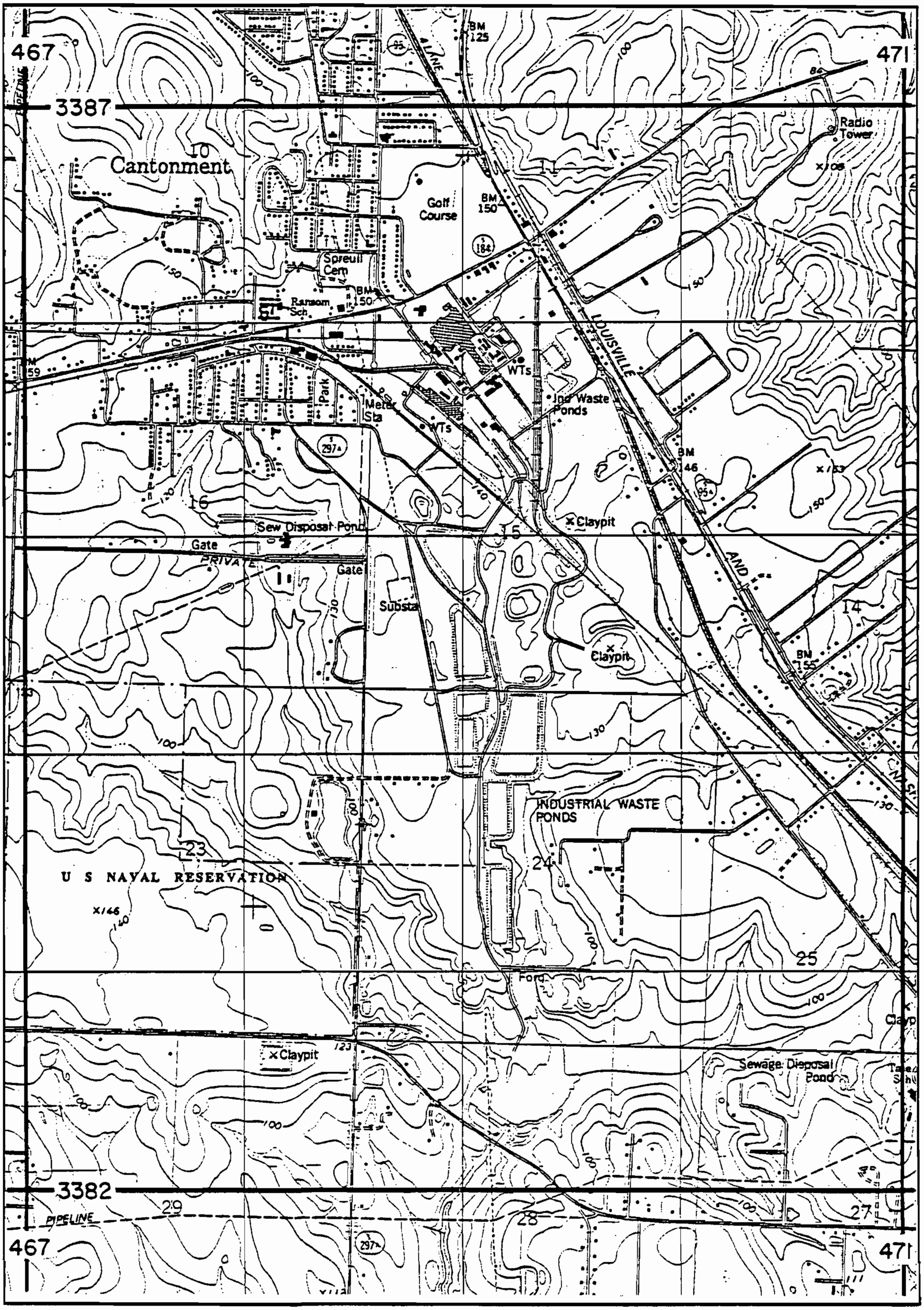
The drying system temperature is held between 275 and 350°F by manual adjustments of temperature control water which is added to the paddle mixer.

The two fluid beds, calcining and cooling, are maintained at the desired levels by bed level recording controllers. Pressure taps sense the fluid bed depth by measuring a differential pressure across the fluid bed. This pressure signal is transmitted to the level controller which automatically adjusts the transfer valve which controls pellet flow from the bed thereby maintaining the fluid bed at the desired preset level or depth.

RECEIVED July 13, 1965. Presented at the 19th Alkaline Pulping Conference, jointly sponsored by TAPPI and Technical Section, CPPA, held in Murray Bay, Que., June 22–25, 1965.

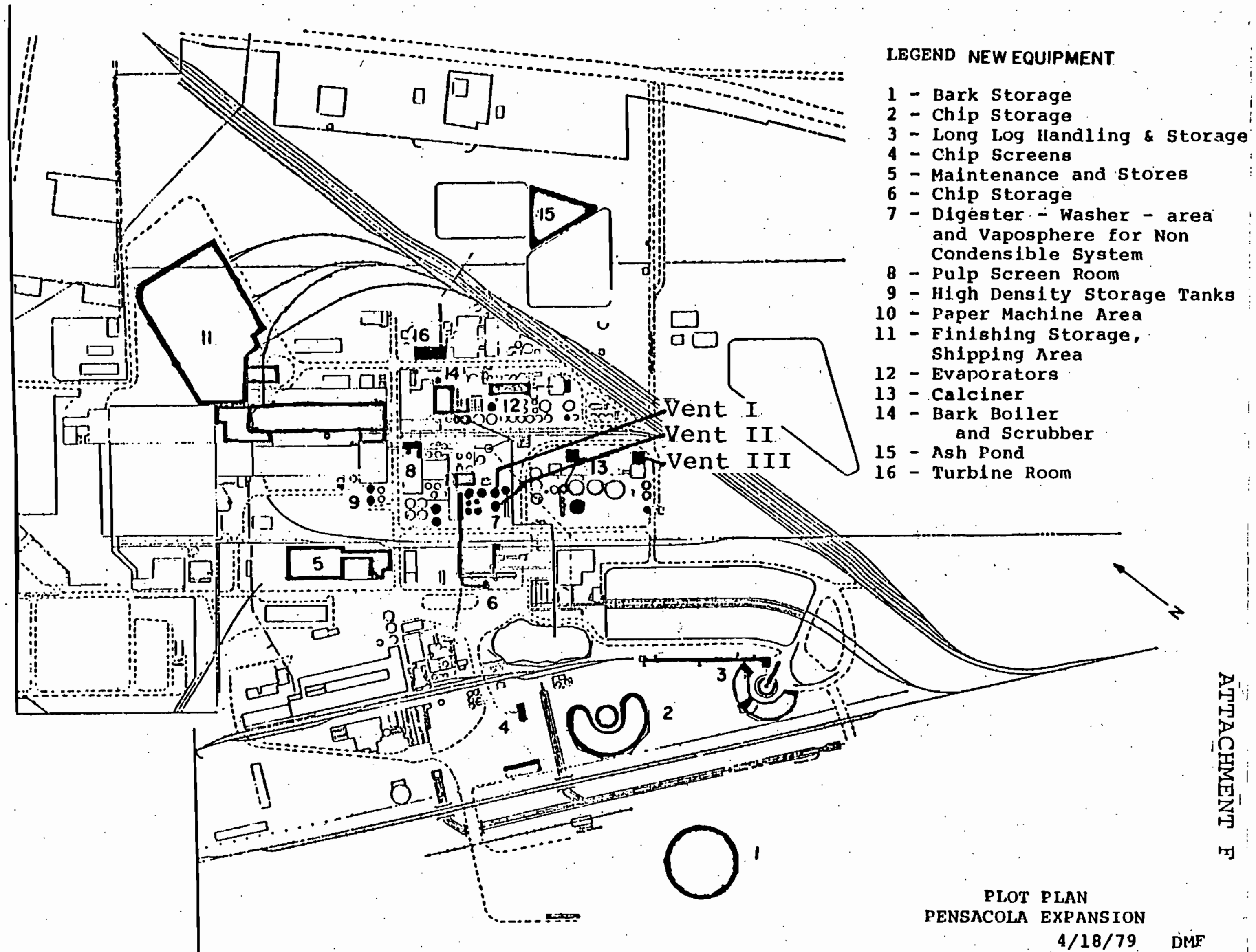
ATTACHMENT F

LOCATION OF EMISSION POINTS



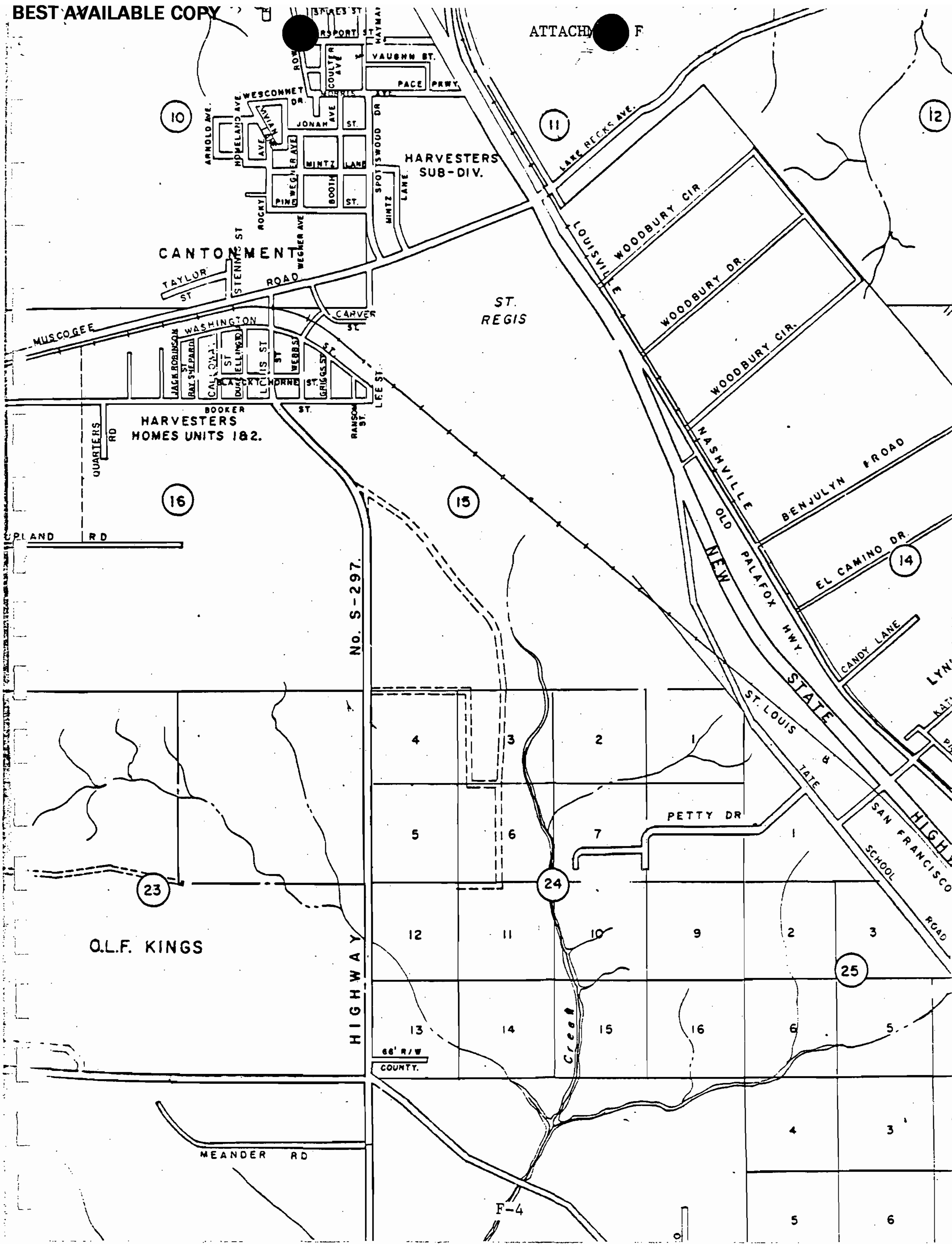
ENGINEERING-SCIENCE

ATTACHMENT F



PLOT PLAN
PENSACOLA EXPANSION
4/18/79 DMF

ATTACH F



VAUGHN ST.
PACE PRWY.
WESCONNET DR.
JONAH ST.
ARNOLD AVE.
HOMELAND AVE.
MINTZ LANE
SPOTTSWOOD DR
HARVESTERS SUB-DIV.
PINE
BOOTH ST.
MINTZ LANE
ROCKY
WEGNER AVE
CANTONMENT
TAYLOR ST
STENNIS ST
ROAD
CARVER ST
MUSCOGEE
WASHINGTON
JACK ROBINSON ST
RAY SHEPARD
CALLOWAY
DUKE ELLINGTON ST
LOUIS ST
WEBBS
GRIGGS ST
LEE ST
BOOKER ST.
RANSOM ST.
HARVESTERS HOMES UNITS 1&2.
QUARTERS RD
UPLAND RD
No. S-297.
HIGHWAY
ST. REGIS
LAKE BECKS AVE.
LOUISVILLE
WOODBURY CIR.
WOODBURY DR.
NASHVILLE
OLD PALAFOX HWY.
NEW STATE
BENJULYN ROAD
EL CAMINO DR.
CANDY LANE
ST. LOUIS & TATE
SAN FRANCISCO
SCHOOL ROAD
PETTY DR
O.L.F. KINGS
Creek
66' R/W COUNTY.
MEANDER RD
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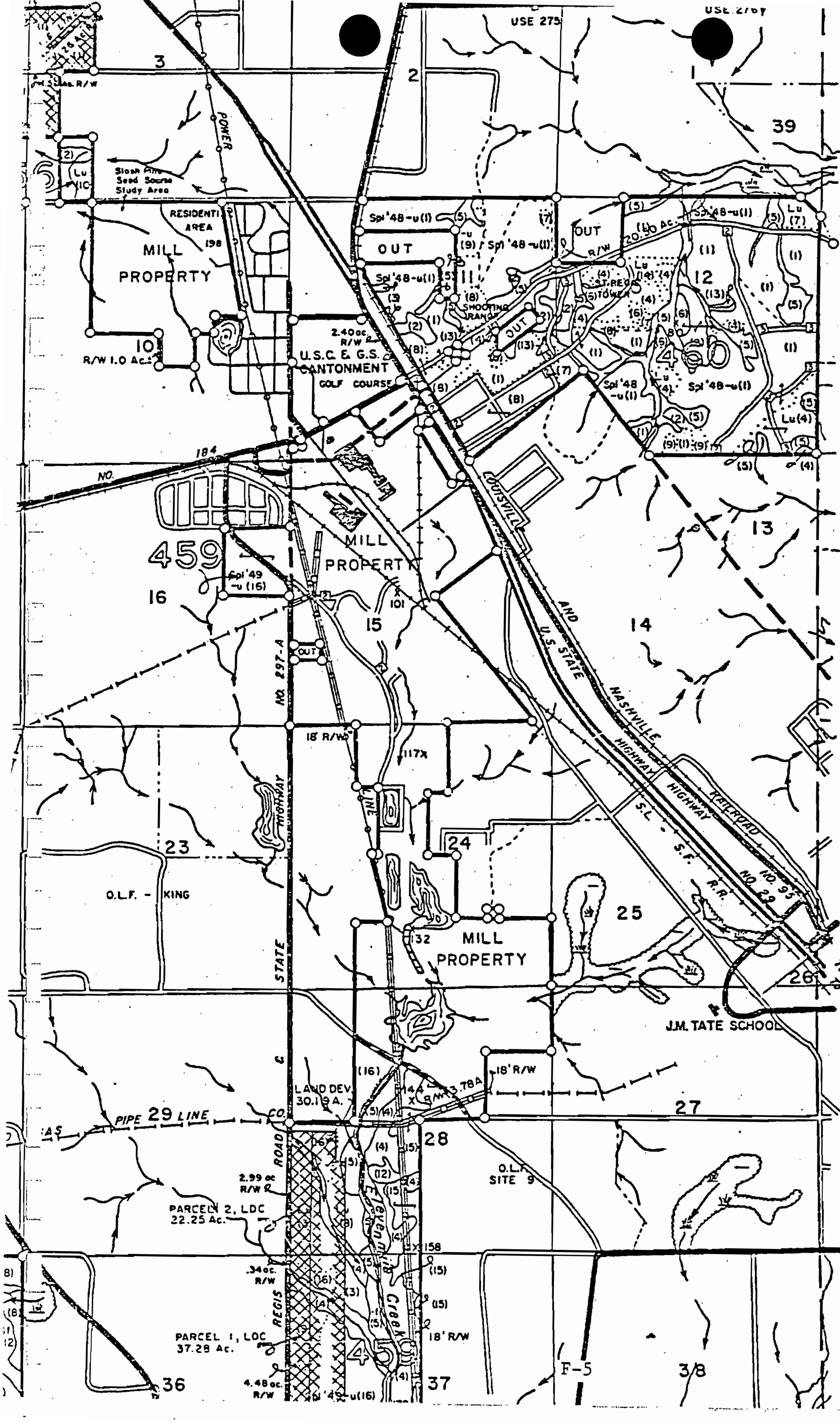
ATTACHMENT F



ATTACHMENT G

DISCUSSION OF SOCIAL IMPACTS

We could not distinguish any difference in social effects solely due to the control technologies. However, there is a definite social impact from the mill expansion.

Social Impact

The mill expansion will result in a definite social benefit for Escambia County, Florida. Additional jobs are expected during the construction phase of the project. The number of permanent new jobs resulting from this expansion is not known at present.

The mill will produce paper which is eventually used to package other materials. This product is in great demand and will likely be used over the next decade as a packaging material. In this respect is is a useful product that will enhance our general well being.

There is one other social advantage. The expanded plant will include new electrical generators. This means that less electrical power will have to be purchased from the power company. The power to be generated by St. Regis will be with waste wood, a renewable resource, rather than oil, coal, or gas which is what the power company would use to produce electrical energy.

The additional production at the mill will result in additional taxes and revenue for Escambia County. In sum, there will be a positive social benefit from the expanded mill.

Assessment of Environmental Impact from the Source

The site for the mill expansion will be located within the property boundaries of the existing mill.

Water discharge to Eleven Mile Creek from the expanded mill will remain within the present discharge permit limits.

The only environmental effects will result from air pollutants discharged to the atmosphere. Preliminary estimates of the maximum impact of tsp from these new sources showed concentrations less than 0.8 $\mu g/m^3$ on an annual basis. Thus the new sources will not have a significant impact on air quality in this area.

ATTACHMENT H

MODELING RESULTS

BEST AVAILABLE COPY

SUMMARY OF CONTROL INPUT

ST REGIS

NUMBER OF STRATEGIES: 0

	SO2	PART	STRATEGIES
HALF LIFE (HRS):	0.	0.	0.
BACKGROUND LEVELS:	0.	0.	
SELECTED AVERAGING PERIODS: 0. 0. 0. 0. 0. 0.			

CONTROL FLAGS:

ISTAR	17	01-12 MONTHLY, 13-16 SEASONAL, 17 ANNUAL
ICONTR	0	0 - OBTAINS SOURCE CONTRIBUTION FILE, >0 - DELETES SOURCE CONTRIBUTION FILE
NSEL12	0	0 - NO STATISTICAL OUTPUT, 1 - SO2 ONLY, 2 - PARTICULATE ONLY, 3 - SO2 AND PARTICULATE
NPOLUT	0	0 - SO2 AND PARTICULTE, 1 - SO2 ONLY, 2 - PARTICULATE ONLY
IFLAG	0	0 - COMPUTE AND ADJUST W/ CALIBRATION FACTORS, 1 - CALIBRATE AND COMPUTE, 2 - CALIBRATE ONLY
IBRIGGS	1	0 - HOLLAND PLUME RISE EQUATION, 1 - BRIGGS PLUME RISE EQUATION
NSEL5	0	0 - NO SELECTED RECEPTORS, 1 - SO2 ONLY, 2 - PARTICULATE ONLY, 3 - SO2 AND PARTICULATE
NSTAB	6	0 - STAR CONSISTS OF A-E, 6 - STAR CONSISTS OF A-F
IPUNCH	1	0 - DECK, 1 - NO DECK

ST REGIS

SOURCE DATA

SOURCE NUMBER	SOURCE ID.	SOURCE LOCATION (KILOMETERS)		SOURCE AREA SQUARE KILOMETERS	ANNUAL SOURCE EMISSION RATE (TONS/DAY)		STACK DATA			
		HORIZONTAL	VERTICAL		SO2	PART	HT (FT)	DIAM (FT)	VEL (FPS)	TEMP (DEG.F)
1	CALCINER	-0.2	-0.2	0.0	1.001	0.101	88.0	3.0	35.0	160.

ST REGIS

METEOROLOGICAL INPUT DATA FOR ANNUAL

MIXING DEPTH = 1000. METERS
AMBIENT TEMPERATURE = 70. DEGREES,FAHRENHEIT
AMBIENT PRESSURE = 1014. MILLIBARS

STABILITY CLASS 1

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.00115	.00078	.0	.0	.0	.0
NNE	.00072	.00047	.0	.0	.0	.0
NE	.00046	.00030	.0	.0	.0	.0
ENE	.00037	.00026	.0	.0	.0	.0
E	.00063	.00042	.0	.0	.0	.0
ESE	.00041	.00031	.0	.0	.0	.0
SE	.00021	.00016	.0	.0	.0	.0
SSE	.00053	.00032	.0	.0	.0	.0
S	.00063	.00050	.0	.0	.0	.0
SSW	.00040	.00031	.0	.0	.0	.0
SW	.00025	.00019	.0	.0	.0	.0
WSW	.00041	.00024	.0	.0	.0	.0
W	.00080	.00054	.0	.0	.0	.0
WNW	.00058	.00042	.0	.0	.0	.0
NW	.00047	.00037	.0	.0	.0	.0
NNW	.00104	.00089	.0	.0	.0	.0

ST REGIS

METEOROLOGICAL INPUT DATA FOR ANNUAL

STABILITY CLASS 2

	WINDSPEED CLASS					
WIND DIRECTION	1	2	3	4	5	6
N	.00284	.00402	.00180	.0	.0	.0
NNE	.00227	.00247	.00120	.0	.0	.0
NE	.00203	.00180	.00063	.0	.0	.0
ENE	.00176	.00204	.00072	.0	.0	.0
E	.00327	.00358	.00123	.0	.0	.0
ESE	.00149	.00178	.00072	.0	.0	.0
SE	.00107	.00130	.00041	.0	.0	.0
SSE	.00132	.00124	.00064	.0	.0	.0
S	.00178	.00204	.00108	.0	.0	.0
SSW	.00096	.00087	.00058	.0	.0	.0
SW	.00072	.00057	.00041	.0	.0	.0
WSW	.00102	.00105	.00053	.0	.0	.0
W	.00168	.00153	.00072	.0	.0	.0
WNW	.00140	.00138	.00067	.0	.0	.0
NW	.00118	.00161	.00082	.0	.0	.0
NNW	.00180	.00309	.00163	.0	.0	.0

ST REGIS

METEOROLOGICAL INPUT DATA FOR ANNUAL

STABILITY CLASS 3

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.00149	.00372	.00685	.00095	.00006	.00001
NNE	.00127	.00327	.00519	.00074	.00003	.0
NE	.00100	.00256	.00300	.00049	.00002	.0
ENE	.00105	.00259	.00413	.00025	.00001	.0
E	.00201	.00475	.00647	.00065	.00002	.0
ESE	.00109	.00195	.00277	.00014	.00001	.0
SE	.00059	.00129	.00176	.00024	.00001	.0
SSE	.00046	.00137	.00300	.00035	.00003	.00001
S	.00108	.00282	.00806	.00100	.0	.0
SSW	.00063	.00163	.00406	.00056	.00001	.00001
SW	.00052	.00123	.00167	.00019	.00001	.00001
WSW	.00076	.00152	.00242	.00027	.00002	.0
W	.00115	.00226	.00266	.00015	.0	.0
WNW	.00067	.00176	.00253	.00030	.0	.0
NW	.00064	.00160	.00288	.00040	.0	.0
NNW	.00087	.00239	.00509	.00083	.00002	.0

ST REGIS

METEOROLOGICAL INPUT DATA FOR ANNUAL

STABILITY CLASS 4

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.00205	.00593	.01526	.01786	.00440	.00102
NNE	.00146	.00494	.00962	.00707	.00104	.00013
NE	.00155	.00417	.00757	.00461	.00048	.00003
ENE	.00155	.00437	.00837	.00510	.00059	.00009
E	.00340	.00933	.01548	.00920	.00076	.00014
ESE	.00201	.00573	.00823	.00457	.00072	.00022
SE	.00169	.00437	.00726	.00467	.00068	.00037
SSE	.00117	.00396	.01002	.00779	.00076	.00023
S	.00220	.00711	.01818	.01446	.00176	.00030
SSW	.00124	.00393	.01073	.01005	.00138	.00024
SW	.00090	.00234	.00510	.00408	.00087	.00010
WSW	.00116	.00344	.00482	.00376	.00053	.00001
W	.00112	.00355	.00468	.00260	.00055	.00013
WNW	.00074	.00224	.00363	.00406	.00130	.00025
NW	.00062	.00199	.00510	.00870	.00273	.00105
NNW	.00100	.00309	.00863	.01452	.00493	.00138

ST REGIS

METEOROLOGICAL INPUT DATA FOR ANNUAL

STABILITY CLASS 5

WIND DIRECTION	WINDSPEED CLASS 1	2	3	4	5	6
N	.02305	.02354	.01392	.0	.0	.0
NNE	.01424	.01368	.00525	.0	.0	.0
NE	.01194	.01142	.00340	.0	.0	.0
ENE	.00885	.00933	.00266	.0	.0	.0
E	.01602	.01561	.00379	.0	.0	.0
ESE	.00724	.00681	.00104	.0	.0	.0
SE	.00532	.00512	.00048	.0	.0	.0
SSE	.00505	.00564	.00094	.0	.0	.0
S	.01129	.01587	.00342	.0	.0	.0
SSW	.00806	.01083	.00312	.0	.0	.0
SW	.00855	.00945	.00247	.0	.0	.0
WSW	.01133	.01107	.00329	.0	.0	.0
W	.01536	.01168	.00317	.0	.0	.0
WNW	.00703	.00565	.00259	.0	.0	.0
NW	.00578	.00579	.00380	.0	.0	.0
NNW	.01052	.00993	.00764	.0	.0	.0

ST REGIS

INPUT REGRESSION PARAMETERS ARE:

POLLUTANT	Y-INTERCEPT	SLOPE
SO2	0.0	10.0000
PARTICULATES	0.0	10.0000

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER) SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
1	-10.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	-10.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	-10.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	-10.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	-10.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	-10.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	-10.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	-10.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	-10.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	-10.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	-10.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	-10.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	-10.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	-10.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	-10.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	-10.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	-10.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	-10.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	-10.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	-10.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	-10.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	-9.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	-9.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	-9.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	-9.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	-9.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	-9.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	-9.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	-9.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	-9.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	-9.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	-9.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	-9.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	-9.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	-9.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	-9.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	-9.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	-9.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	-9.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	-9.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
41	-9.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	-9.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	-8.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	-8.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	-8.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	-8.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	-8.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	-8.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	-8.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	-8.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	-8.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	-8.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53	-8.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54	-8.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	-8.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	-8.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	-8.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	-8.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	-8.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	-8.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	-8.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62	-8.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	-8.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	-7.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65	-7.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	-7.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	-7.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	-7.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69	-7.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	-7.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71	-7.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72	-7.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73	-7.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74	-7.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75	-7.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76	-7.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77	-7.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78	-7.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79	-7.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	-7.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
81	-7.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82	-7.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83	-7.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84	-7.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85	-6.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86	-6.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87	-6.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
88	-6.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
89	-6.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
90	-6.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
91	-6.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
92	-6.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
93	-6.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
94	-6.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
95	-6.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
96	-6.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
97	-6.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
98	-6.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
99	-6.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
100	-6.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
101	-6.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
102	-6.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
103	-6.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
104	-6.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
105	-6.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
106	-5.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
107	-5.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
108	-5.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
109	-5.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
110	-5.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
111	-5.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
112	-5.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
113	-5.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
114	-5.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
115	-5.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
116	-5.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
117	-5.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
118	-5.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
119	-5.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
120	-5.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
121	-5.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
122	-5.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
123	-5.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
124	-5.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
125	-5.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
126	-5.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
127	-4.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
128	-4.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
129	-4.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
130	-4.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
131	-4.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
132	-4.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
133	-4.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
134	-4.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
135	-4.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
136	-4.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
137	-4.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
138	-4.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
139	-4.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
140	-4.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
141	-4.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
142	-4.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
143	-4.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
144	-4.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
145	-4.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
146	-4.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
147	-4.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
148	-3.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
149	-3.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
150	-3.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
151	-3.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
152	-3.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
153	-3.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
154	-3.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
155	-3.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
156	-3.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
157	-3.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
158	-3.0	0.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
159	-3.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
160	-3.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER) SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
161	-3.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
162	-3.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
163	-3.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
164	-3.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
165	-3.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
166	-3.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
167	-3.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
168	-3.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
169	-2.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
170	-2.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
171	-2.0	-8.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
172	-2.0	-7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
173	-2.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
174	-2.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
175	-2.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
176	-2.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
177	-2.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
178	-2.0	-1.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
179	-2.0	0.0	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
180	-2.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
181	-2.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
182	-2.0	3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
183	-2.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
184	-2.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
185	-2.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
186	-2.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
187	-2.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
188	-2.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
189	-2.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
190	-1.0	-10.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
191	-1.0	-9.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
192	-1.0	-8.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
193	-1.0	-7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
194	-1.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
195	-1.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
196	-1.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
197	-1.0	-3.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
198	-1.0	-2.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
199	-1.0	-1.0	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
200	-1.0	0.0	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
201	-1.0	1.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
202	-1.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
203	-1.0	3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
204	-1.0	4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
205	-1.0	5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
206	-1.0	6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
207	-1.0	7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
208	-1.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
209	-1.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
210	-1.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
211	0.0	-10.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
212	0.0	-9.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
213	0.0	-8.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
214	0.0	-7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
215	0.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
216	0.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
217	0.0	-4.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
218	0.0	-3.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
219	0.0	-2.0	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
220	0.0	-1.0	0.	7.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
221	0.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
222	0.0	1.0	0.	4.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
223	0.0	2.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
224	0.0	3.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
225	0.0	4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
226	0.0	5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
227	0.0	6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
228	0.0	7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
229	0.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
230	0.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
231	0.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
232	1.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
233	1.0	-9.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
234	1.0	-8.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
235	1.0	-7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
236	1.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
237	1.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
238	1.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
239	1.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
240	1.0	-2.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

NO.	RECEPTOR LOCATION (KM) HORIZ	VERT	RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER) SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
241	1.0	-1.0	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
242	1.0	0.0	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
243	1.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
244	1.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
245	1.0	3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
246	1.0	4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
247	1.0	5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
248	1.0	6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
249	1.0	7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
250	1.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
251	1.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
252	1.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
253	2.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
254	2.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
255	2.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
256	2.0	-7.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
257	2.0	-6.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
258	2.0	-5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
259	2.0	-4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
260	2.0	-3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
261	2.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
262	2.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
263	2.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
264	2.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
265	2.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
266	2.0	3.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
267	2.0	4.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
268	2.0	5.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
269	2.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
270	2.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
271	2.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
272	2.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
273	2.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
274	3.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
275	3.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
276	3.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
277	3.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
278	3.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
279	3.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
280	3.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
281	3.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
282	3.0	-2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
283	3.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
284	3.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
285	3.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
286	3.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
287	3.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
288	3.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
289	3.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
290	3.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
291	3.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
292	3.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
293	3.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
294	3.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
295	4.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
296	4.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
297	4.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
298	4.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
299	4.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
300	4.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
301	4.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
302	4.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
303	4.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
304	4.0	-1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
305	4.0	0.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
306	4.0	1.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
307	4.0	2.0	0.	1.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
308	4.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
309	4.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
310	4.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
311	4.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
312	4.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
313	4.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
314	4.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
315	4.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
316	5.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
317	5.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
318	5.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
319	5.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
320	5.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
321	5.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
322	5.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
323	5.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
324	5.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
325	5.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
326	5.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
327	5.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
328	5.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
329	5.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
330	5.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
331	5.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
332	5.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
333	5.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
334	5.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
335	5.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
336	5.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
337	6.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
338	6.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
339	6.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
340	6.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
341	6.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
342	6.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
343	6.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
344	6.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
345	6.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
346	6.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
347	6.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
348	6.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
349	6.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
350	6.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
351	6.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
352	6.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
353	6.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
354	6.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
355	6.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
356	6.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
357	6.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
358	7.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
359	7.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
360	7.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
361	7.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
362	7.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
363	7.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
364	7.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
365	7.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
366	7.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
367	7.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
368	7.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
369	7.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
370	7.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
371	7.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
372	7.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
373	7.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
374	7.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
375	7.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
376	7.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
377	7.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
378	7.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
379	8.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
380	8.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
381	8.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
382	8.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
383	8.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
384	8.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
385	8.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
386	8.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
387	8.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
388	8.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
389	8.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
390	8.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
391	8.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
392	8.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
393	8.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
394	8.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
395	8.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
396	8.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
397	8.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
398	8.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
399	8.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
400	9.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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ST REGIS

RECEPTOR NO.	LOCATION (KM) HORIZ	VERT	SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
			RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER)											
401	9.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
402	9.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
403	9.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
404	9.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
405	9.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
406	9.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
407	9.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
408	9.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
409	9.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
410	9.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
411	9.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
412	9.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
413	9.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
414	9.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
415	9.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
416	9.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
417	9.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
418	9.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
419	9.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
420	9.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
421	10.0	-10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
422	10.0	-9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
423	10.0	-8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
424	10.0	-7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
425	10.0	-6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
426	10.0	-5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
427	10.0	-4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
428	10.0	-3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
429	10.0	-2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
430	10.0	-1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
431	10.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
432	10.0	1.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
433	10.0	2.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
434	10.0	3.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
435	10.0	4.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
436	10.0	5.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
437	10.0	6.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
438	10.0	7.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
439	10.0	8.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
440	10.0	9.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

RECEPTOR NO.	RECEPTOR LOCATION (KM) HORIZ	VERT	RECEPTOR CONCENTRATION DATA PREDICTED ARITHMETIC MEAN (MICROGRAMS/CU. METER) SO2	PART	STG1	STG2	STG3	STG4	STG5	STG6	STG7	STG8	STG9	STG10
441	10.0	10.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

SOURCE CONTRIBUTIONS TO FIVE MAXIMUM RECEPTORS

ANNUAL SO2

MICROGRAMS PER CUBIC METER

SOURCE	RECEPTOR 220	RECEPTOR 222	RECEPTOR 200	RECEPTOR 219	RECEPTOR 199
1	100.00 % 0.0703	100.00 % 0.0441	100.00 % 0.0420	100.00 % 0.0411	100.00 % 0.0322
BACK-GROUND	0.0 % 0.	0.0 % 0.	0.0 % 0.	0.0 % 0.	0.0 % 0.
TOTAL	100.0 % 0.0703	100.0 % 0.0441	100.0 % 0.0420	100.0 % 0.0411	100.0 % 0.0322

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ST REGIS

SOURCE CONTRIBUTIONS TO FIVE MAXIMUM RECEPTORS

ANNUAL PARTICULATES

MICROGRAMS PER CUBIC METER

SOURCE	RECEPTOR 220	RECEPTOR 222	RECEPTOR 200	RECEPTOR 219	RECEPTOR 199
1	100.00 % 7.0982	100.00 % 4.4502	100.00 % 4.2389	100.00 % 4.1465	100.00 % 3.2565
BACK-GROUND	0.0 % 0.	0.0 % 0.	0.0 % 0.	0.0 % 0.	0.0 % 0.
TOTAL	100.0 % 7.0982	100.0 % 4.4502	100.0 % 4.2389	100.0 % 4.1465	100.0 % 3.2565

NOTE: Because all predicted concentrations were less than 1 ug/m^3, ES multiplied the predicted values by 10 in order to provide more detail for the isopleths. The predicted concentrations on this computer printout should be divided by 10 to obtain the predicted impact of TSP and SO_2.

ATTACHMENT I

LETTER OF AUTHORIZATION

ST. REGIS PAPER COMPANY

150 East 42nd Street New York, N.Y. 10017 212 573-6000

June 5, 1979

RECEIVED
JUN 11 1979
ENGINEERING SCIENCE

Mr. Robert V. Kriegel
District Manager
Florida Department of
Environmental Regulation
160 Governmental Center
Pensacola, Florida 32501

Dear Mr. Kriegel:

This letter is to certify that Russell T. Hudson, Resident Manager of the St. Regis Paper Company Kraft Mill in Cantonment, Florida, is authorized to act as the St. Regis Representative with the Department of Environmental Regulation.

Sincerely,

ST. REGIS PAPER COMPANY
Kraft & Recycled Products

J. N. Bowersock

James N. Bowersock
Senior Vice President

JNB/mbh

CC: Messrs.
D. M. Ferguson
R. T. Hudson
S. K. Pratt