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MAGNESIA FGD PROCESS TESTING ON A COAL-FIRED POWER PLANT

Industrial Environmental Research Laboratory
Office of Research and Development
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MAGNESIA FGD PROCESS TESTING ON A COAL-FIRED POWER PLANT

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ABSTRACT

This field measurement program was initiated with the overall objective of determining the operability and reliability of the Chemico magnesium oxide venturi scrubber in operation at Potomac Electric Power Company's Dickerson Generating Station, located in Frederick , Maryland.

To achieve this objective, a continuous source-monitoring station was installed at the scrubber, and was complemented by a field analytical laboratory intended for the measurement and analysis of various process streams. These facilities continuously monitored process and emission variables during a four month period between October 1974 and January 1975; and later during the month of August 1975.

Scrubber operation was evaluated during periods of steady-state operation, and transient operation. The latter included periods of start-up, shutdown, and malfunction. During the test period, the scrubber was available for approximately 48 percent of the time. This percent availability included all levels of operation, steady-state and transient alike. It is estimated that of the time that the system was available, approximately 80 percent was steady-state where the system was operating normally.

This test program showed that, although scrubber availability was not all that was desired due to problems with logistics in supplying raw materials (MgO), and to mechanical problems mainly attributable to under-design in such areas as piping, slurry pumps, and other auxiliary equipment, the basic scrubber concept and design was one that should meet critical criteria once these problems are remedied.

ACKNOWLEDGEMENTS

York Research Corporation wishes to express its appreciation to the Potomac Electric Power Company's Dickerson Generating Station personnel for their cooperation during the test program. Appreciation is extended also to Dr. Charles Chatlynne and Mr. Robert Hendriks of the Industrial Environmental Research Laboratory - Research Triangle Park (IERL-RTP), and to the Chemical Construction Company (Chemico).

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SUMMARY

This report presents the results of a five-month study of an 95 MW MgO Demonstration FDG System on a coal-fired utility boiler. The site chosen for this study was the Dickerson Generating Station which is operated by Potomac Electric Power Company. This facility had been fitted with a Chemico/Basic Two-Stage MgO Venturi scrubber.

This test program showed that, although scrubber availability was not all that was desired due to problems with logistics in supplying raw materials (MgO), and to mechanical problems mainly attributable to under-design in such areas as piping, slurry pumps, and other auxiliary equipment, the basic scrubber concept and design was one that should meet critical criteria once these problems are remedied.

This report discusses scrubber operation during steady-state and transient operating conditions, and the basic chemical characteristics of the process streams. Recommendations are provided relative to the unit's operation and maintenance from the viewpoint of improvements in mechanical design to improve the availability.

Due to the limited availability during the test program which did not provide the opportunity for full system characterization and optimization, and to the system's indicated strengths, recommendation is given that further testing of the MgO FGD System be carried out in order to better characterize the process.

1.0 INTRODUCTION

York Research Corporation (YRC) was contracted by the Industrial Environmental Research Laboratory - Research Triangle Park (IERL-RTP) of the Environmental Protection Agency (EPA) to perform a test program upon a Magnesia Flue Gas Desulfurization (FGD) process on a coal-fired utility boiler. The objectives of the program were to characterize both emissions from, and the process operation of, the FGD system under both steady-state and transient operating conditions. This was to be achieved through the installation and operation of a continuous emission monitoring program, which was supplemented by manual emission measurements using standard EPA techniques, and by the sampling of certain process streams.

The site chosen for the test program was the Dickerson Generating Station, operated by the Potomac Electric Power Company (PEPCO). This station had been equipped with a Chemico/Basic MgO FGD demonstration scrubber system.

Mr. Roland Glenn of Combustion Processes, Inc. was involved in the program as a field consultant for the purpose of assisting with process evaluation.

During the test program, PEPCO plant operators and the Chemical Construction Company were responsible for the operation, optimization, repair, and maintenance of the demonstration system. Data presented in this report are results of YRC's observations and measurements made during the program.

The test program commenced in October 1974 and ran continuously until the end of January 1975. At that time, there was a scheduled

outage for boiler repairs. During this period, a considerable amount of repair work was performed upon the FGD system. In August 1975, the test program was resumed and ran until the end of the month, at which time it was terminated due to lack of further committment on the part of PEPCO to supply the additional necessary maintenance funds. The U.S. EPA did have funds allocated for the continuation of the operation of the regeneration facility.

The objectives of the program were to characterize scrubber emissions and variations in emissions, as well as the performance factors of the FGD process during:

- Steady-state operating conditions
- Transient operating conditions

Steady-state conditions are defined as being in effect when the flue gas flow, boiler operating conditions, and fuel constituents were not fluctuating, and when scrubber process streams were in an equilibrium state.

Steady-state conditions were determined to be in effect when after startup, the scrubber had settled down into its normal operating process condition. Conversely, transient conditions were when this mode of operation was not in effect (e.g., during scrubber startup, shutdown, or malfunction).

2.0 PLANT DESCRIPTION

The No. 3 boiler at PEPCO's Dickerson Generating Station is a tangentially fired, pulverized coal-fired unit rated at 190 MW (maximum continuous rating). It was installed by Combustion Engineering in 1962 and is designed to produce 1,300,000 pounds of steam per hour at 2480 lbs /in^2 at 1000^{o}F superheat. The unit incorporates a separated twin furnace design with economizers, waterwalls and generating surfaces, two stage superheat with spray attemperation, reheat, and provision for dry bottom ash removal. Four Raymond Bowl Mill Pulverizers feed 32 tangential burners; i.e., one burner at each of the four levels at each furnace corner. The boiler is equipped with two steam coil air heaters, and two Ljungstrom rotary air heaters for combustion air preheat. There are two forced draft (FD) and induced draft (ID) fans for controlling furnace pressure and airflow, two forced circulation pumps to maintain water flow, and a Bailey combustion control system. The boiler is also provided with pilot and warmup oil torches (No. 2 Oil) which can be used as load carrying burners during periods of firing low volatile or wet coal.

A Research Cottrell electrostatic precipitator (ESP) is installed in the exhaust gas network of boiler Unit No. 3 downstream of the combustion air preheater. This unit consists of two Opzel plate precipitators in the same housing, separated by an internal partition. Each precipitator is divided into 2 units containing 3 sections of 6 foot plates along 21 ducted segments, with discharge electrodes (wires) suspended between parallel plate collectors. Twelve Syntron vibrators are used on the discharge electrodes and 24 magnetic impulse rappers (continuous cycle) are used on the collection plates to dislodge collected matter. Each unit is designed for a particle removal efficiency of 97.5 percent, at design flow rate of 492,000

cubic feet per minute (CFM) at 245°F. Boiler exhaust gases typically contained the following:

- 13.0 percent CO_2
- 0.2 percent CO
- 6.0 percent O_2
- 6-10 percent moisture

A typical analysis of the bituminous coal which is fired at the Dickerson Station shows the following:

- Heat Content: 12,154 Btu/lb.
- Nitrogen : 0.96%
- Carbon : 71.30%
- Hydrogen : 4.20%
- Chlorine : 0.10%
- Sulfur : 1.60%
- Oxygen : 4.90%
- Moisture : 1.40%
- Ash : 15.42%

3.0 FGD SYSTEM PROCESS DESCRIPTION

The Chemico/Basic Magnesium Oxide Flue Gas Desulfurization (FGD) system (Figure 3-1) was designed to accomodate approximately one-half (295,000 ACFM at 259°F) of the exhaust gas from Unit No. 3. This FGD system incorporated the following major processing steps:

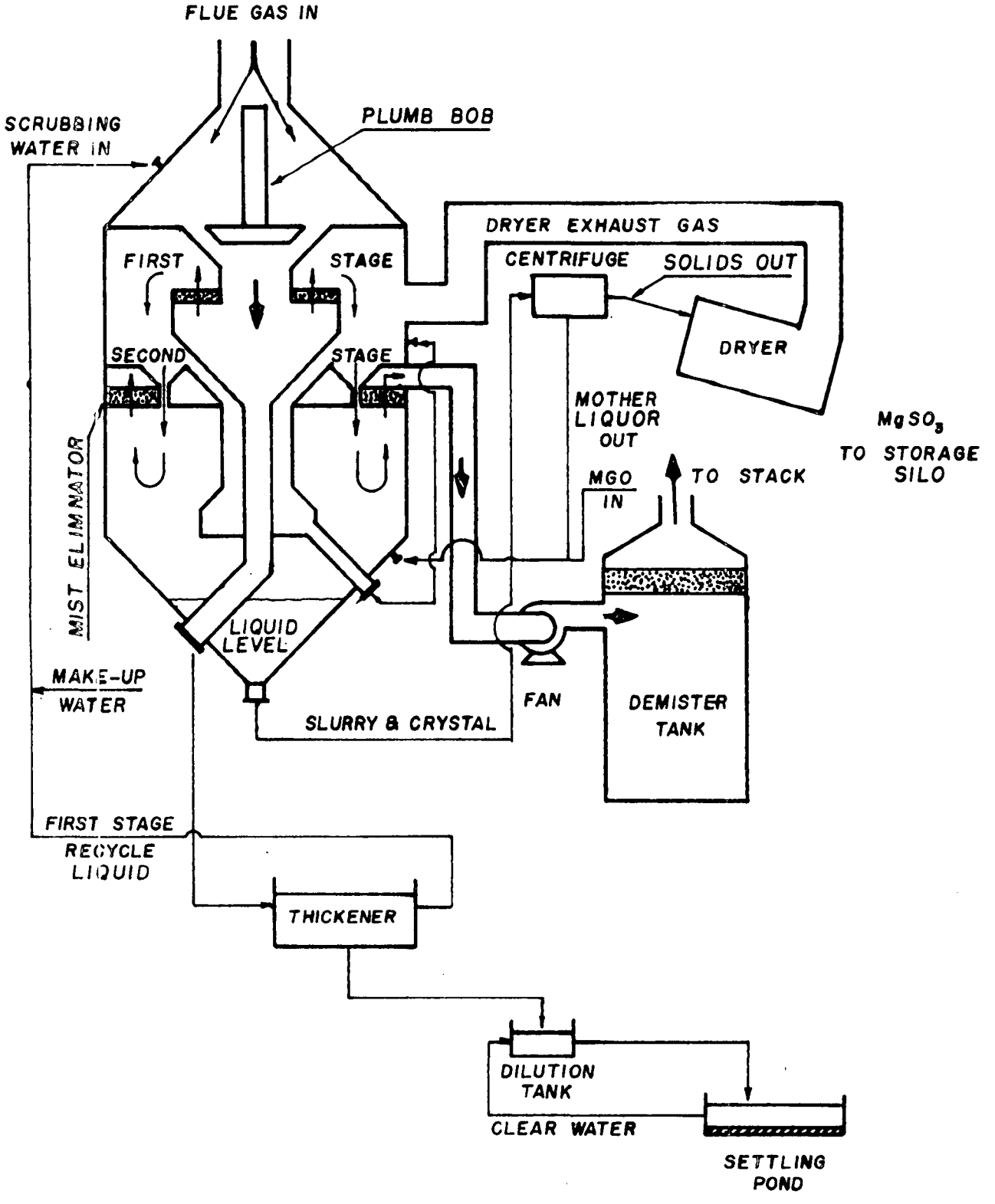
- Flyash removal
- SO_2 removal
- Solids concentration
- Drying
- Dry solids storage
- Calcination

The first five of the above steps were accomplished within the system, while the last was carried out at the Essex Chemical Company's sulfuric acid plant in Rumford, Rhode Island.

The total boiler-scrubber system configuration is shown in Figure 3-2, where it is noted that appropriate by-passes were provided such that gas flows to both the scrubber and ESP could be adjusted to control the flow through each unit.

In its operating mode, the flue gas from the boiler was drawn into the scrubber by means of an induced draft (ID) fan which was regulated by the scrubber operators. This permitted adjustment of the volume of flue gas entering the scrubber inlet. Design flow of the scrubber was approximately 295,000 ACFM, which was about one-half of the full load gas flow of the boiler. The flow diagram for the entire scrubber is shown in Figure 3-3.

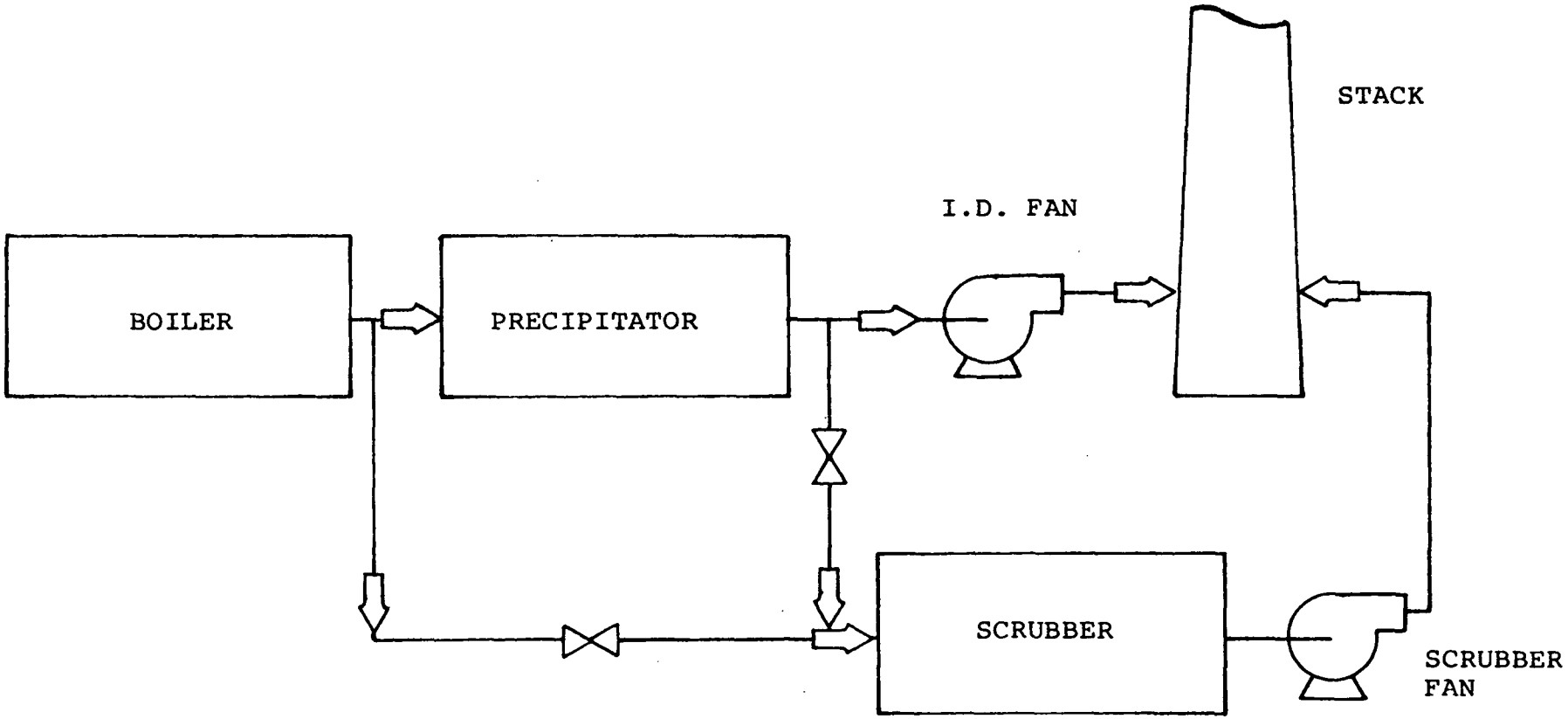
The FGD system was designed as a two stage system, with the first stage providing flyash removal and the second stage SO_2 removal.



SCHEMATIC DIAGRAM OF CHEMICO WET SCRUBBING SYSTEM

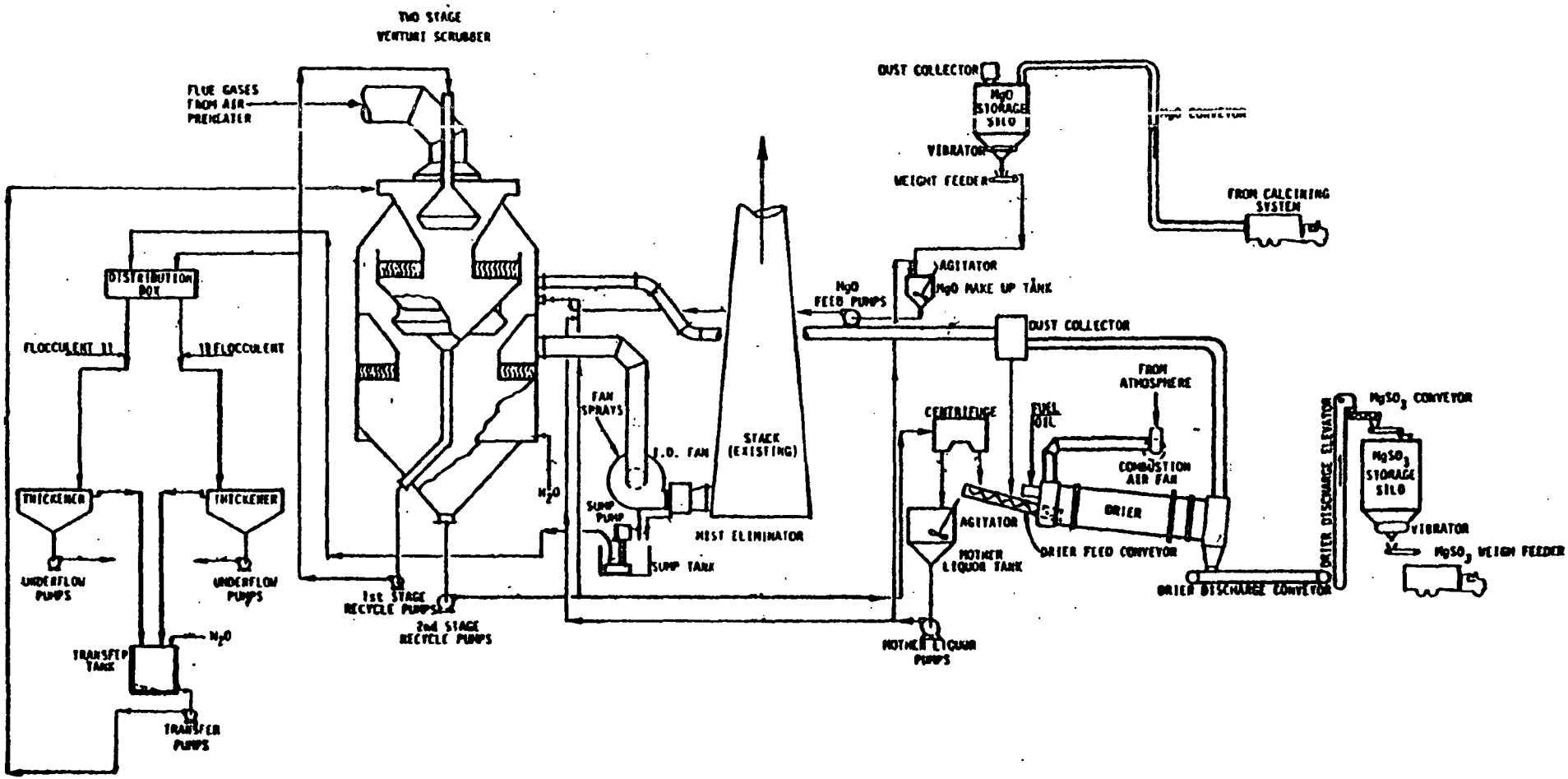
UNIT NO. 3, PEPCO-DICKERSON

Figure 3-1



BOILER-SCRUBBER CONFIGURATION

FIGURE 3-2



FLOW DIAGRAM OF THE FGD SYSTEM

FIGURE 3-3

3.1 First Stage - Flyash Removal

The first stage was an adjustable throat venturi, where the flue gas was cooled from 250°F to 120°F and saturated with water vapor. This stage was used for flyash (particle) control only, and its re-circulating liquid stream was separate and independent from that of the second stage. Ash-laden water was circulated at a nominal 2 percent solids concentration. The adjustable venturi automatically controlled the first stage pressure drop, which was maintained at 11 inches (H_2O). Design particle removal efficiency was 99.0 percent.

A 980 gal /min (GPM) bleed stream from the first stage recycle line carried ash to the thickeners. A flocculant was used to aid settling in the thickeners. Thickener underflow (20 GPM at 40 percent solids) was discharged to a dilution tank where water was added, and the mixture pumped back to a settling pond. The overflow cascaded through a total of four ponds in series, and the water from the lowest pond was then pumped back to the dilution tank. The thickener overflow was pumped back into the scrubber's first stage. This closed-loop operation was maintained within first stage operation.

3.2 Second Stage - SO_2 Removal

Flue gas, after leaving the first stage, passed upward through an annular mist eliminator, and then downward through the scrubber's second stage. Within the second stage, magnesium oxide (MgO) was added to the scrubbing water. This allowed the SO_2 in the flue gas to diffuse into the water droplets, thus removing it from the gas stream. In this process, the SO_2 chemically reacts with the MgO, forming hydrated magnesium sulfites ($MgSO_3 \cdot nH_2O$), and to a lesser degree, magnesium sulfate ($MgSO_4$).

Flue gas and entrained liquor entered the separator

portion of the absorber through a central downcomer. The liquor fell to the lower section of the separator which served as an integral storage reservoir, while the gas passed upward through the second stage mist eliminators and was exhausted through the stack to the atmosphere.

3.3 Solids Concentration

A 170 GPM bleed from the absorption system entered a 36 inch by 72 inch solid bowl centrifuge where hydrated magnesium sulfite and magnesium sulfate crystals, and unreacted MgO were separated from the mother liquor. The mother liquor was returned to the second stage absorption system, and the centrifuged wet cake entered the dryer.

3.4 Drying

The wet cake containing hydrated magnesium sulfite, magnesium sulfate, MgO and surface moisture was dried by direct firing to remove free and combined moisture. Exhaust gas from the dryer passed through a cyclone dust collector, and back into the scrubber's second stage.

3.5 Dry Solids Storage

The anhydrous $MgSO_3$ and $MgSO_4$ material was conveyed from the dryer to a storage silo (capacity: 200 tons) where it was kept until it was transported to the sulfuric acid plant for calcination.

3.6 Calcination

The dry cake was transported to the Essex Chemical Company's sulfuric acid plant in Rumford, Rhode Island for calcination. Regenerated MgO was returned (with make-up) and stored in the MgO silo (capacity: 100 tons). The MgO slurry was prepared using regenerated MgO, make-up MgO, and mother liquor. This MgO slurry was added as make-up to the absorption recycle liquid circuit (second stage).

3.7 Scrubber Process Control

The control process for this FGD system was relatively simple. Basically, the liquid flow rates through the scrubber were constant and independent of gas load. The first stage of the venturi was automatically adjusted to maintain an 11 inch (H_2O) pressure drop across the venturi. MgO additive feed rate was varied to maintain the slurry pH at a preset point; generally about 7. The pH was measured at the discharge of the second stage re-circulation pump. A downward pH trend triggered the addition of MgO to the system from the MgO make-up tank.

4.0 TEST PROGRAM

During the five months that YRC test personnel were on-site, the following types of testing were performed:

- Continuous monitoring of scrubber emissions
- Measurement of process streams
- Manual testing of gaseous emissions.

Figure 4-1 illustrates the sampling points.

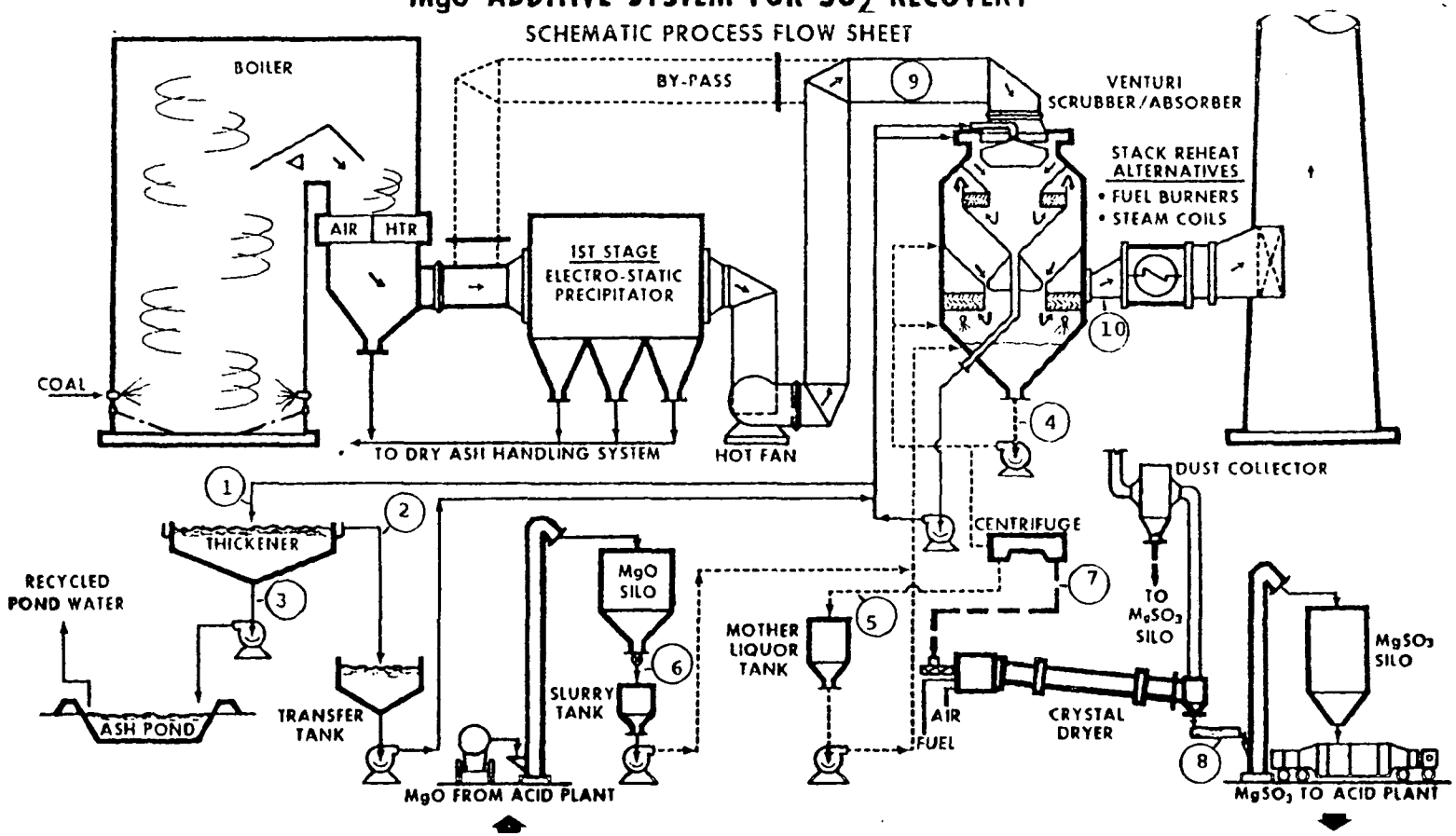
In the planning stage of the project, it was decided to continuously monitor CO, CO_2, and O_2 as indicators of the status of boiler operation, and to provide information regarding leaks in the FGD system. Once the program was underway, it became evident that CO concentrations were maintained at a level so low that instrumental analytical values were unreliable. Thus, after the first few weeks, monitoring of this parameter was discontinued. Oxygen, on the other hand, proved to be a reliable indicator since its level was well maintained within tight bounds in the combustion zone.

4.1 Test Method

4.1.1 Continuous Monitoring Program

Gaseous effluent from the scrubber was continuously monitored during the program to obtain data related to the scrubber's performance during steady-state and transient operating conditions. A continuous monitoring trailer was installed at the base of the scrubber approximately 45 feet from the ducting where the probes were situated. Flue gas, after passing through a series of filters, was carried to the continuous monitoring instruments by means of a heated sample line. The gas flow was conditioned (where moisture was removed) in the

PRECIPITATOR/SCRUBBER - ABSORBER
MgO ADDITIVE SYSTEM FOR SO_2 RECOVERY



SAMPLING LOCATIONS

FIGURE 4-1

trailer before passing to the instruments. Flue gas samples were drawn alternately and sequentially from the inlet and outlet of the scrubber for periods of between 5-20 minutes each. Switching from one location to another was done automatically by a timer-solenoid switching system. The sampling duration from either inlet or outlet were manually adjustable by the trailer operator. This feature allowed shorter sampling times per point during transient conditions than during steady-state conditions.

The parameters measured and the measurement principles were as follows:

Parameter	Method	Instrument
SO_2	Pulsed Fluorescence	Thermo Electron Model 40
NO_x	Chemiluminescence	Thermo Electron Model 10B
CO_2, CO	NDIR	Infra-Red Model 703
O_2	Paramagnetic	Cleveland-Kent Model CKA-1A
Flow	- -	Teledyne-Hastings
Temperature	Thermocouple	- -

Detailed information concerning instrument operation appears in Appendix D.

4.1.2 Measurements of Process Streams

The sampling and analytical program included the collection of data relative to the performance and reliability of the process itself. All of the major process streams were studied and, in addition, some special investigations were made to study various secondary reactions and products. Table 4-1 illustrates the scope of this part of the program. Detailed information concerning the analytical methods used appears in Appendix D.

TABLE 4-1. SCRUBBER CHARACTERIZATION TESTING PROGRAM

Sampling Location	Parameter	Location**	Sampling Frequency	Analytical Method (Appendix D)
FIRST STAGE*				
Bleed	pH	1	8 hours	Electrode
	Magnesium		"	Volumetrically
	Suspended Solids		"	Gravimetrically
	Chloride		"	Turbidimetrically
	Sulfate		"	Colorimetrically
	Sulfite		"	Volumetrically
Thickener Overflow	Suspended Solids	2	"	Gravimetrically
	pH		"	Electrode
	Chloride		"	Turbidimetrically
Thickener Underflow	Suspended Solids	3	"	Gravimetrically
	pH		"	Electrode
	Chloride		"	Turbidimetrically
SECOND STAGE				
Bleed	pH	4	4 hours	Electrode
	% Solids		"	Gravimetrically
	% Mg $SO_3 \cdot 6\ H_2O$		"	Volumetrically
	% Mg SO_4		"	Colorimetrically
	% MgO (Solids)		"	Volumetrically
	% MgO (Total)		"	Volumetrically
	Density		"	Gravimetrically
Mother Liquor	% Solids	5	"	Gravimetrically
	% Mg $SO_3 \cdot 6\ H_2O$		"	Volumetrically
	% MgO (Solids)		"	Volumetrically
	% MgO (Slurry)		"	Volumetrically
	Density		"	Gravimetrically

* Sampled only during the last month of scrubber evaluation (Aug. 1975). Determined during first portion of the program only (Oct., 1974 through Jan., 1975)

** Sampling Location - See Figure 4-1

TABLE 4-1. SCRUBBER CHARACTERIZATION TESTING PROGRAM (CONT'D.)

Sampling Location	Parameter	Location**	Sampling Frequency	Analytical Method (Appendix D)
MgO Belt	% MgO	6	4 hours	Gravimetrically
	% Mg SO_4		"	Colorimetrically
Centrifuge Cake	Density	7	"	Gravimetrically
	% Combined Water		"	Moisture Balance
	% Free Water		"	Gravimetrically
	% Mg SO_3		"	Volumetrically
	% Mg SO_4		"	Colorimetrically
	% MgO		"	Volumetrically
Dryer Product	% Water	8	"	Moisture Balance
	% Mg SO_3		"	Volumetrically
	% Mg SO_4		"	Colorimetrically
	% MgO		"	Volumetrically
	Density		"	Gravimetrically
SPECIAL ANALYSES				
Dryer Product	Iron Content		November 10,11,1974 2 Hour intervals	Colorimetrically
	Trihydrate-Hexahydrate Study		Dec.1974,Jan.1975	Volumetrically
Second Stage Slurry	Time Dependance of pH		Dec., 1974	Electrode
Scrubber 1st Stage	Sulfate		Jan. 10, 1975	Colorimetrically
	Sulfite		"	Volumetrically
	Chloride		"	Turbidimetrically
	Iron		"	Colorimetrically
	Magnesium		"	Volumetrically
	pH		"	Electrode

** Sampling Location - See Figure 4-1.

TABLE 4-1. SCRUBBER CHARACTERIZATION TESTING PROGRAM (CONT'D.)

Sampling Location	Parameter	Location**	Sampling Frequency	Analytical Method (Appendix D)
Centrifuge Cake	Water Content	7	August, 1975	Moisture Balance
Dryer Product	Inert Material	7	August, 1975	By Difference
FIRST STAGE				
Process Water	Magnesium	1	August, 1975	Volumetrically
	Chloride	1	August, 1975	Turbidimetrically
SECOND STAGE				
	Iron	4	August, 1975	Colorimetrically
	Chloride	4	August, 1975	Turbidimetrically
Scrubber Inlet				
	SO_2	9	Continuous	Pulsed Fluorescent
	CO_2	9	Continuous	NDIR
	O_2	9	Continuous	Paramagnetic
	Flow	9	Continuous	- -
	Temperature	9	Continuous	- -
Scrubber Outlet				
	SO_2	10	Continuous	Pulsed Fluorescent
	CO_2	10	Continuous	NDIR
	O_2	10	Continuous	Paramagnetic
	Flow	10	Continuous	- -
	Temperature	10	Continuous	- -

** Sampling location - See Figure 3-1.

4.1.3 Manual Testing of Gaseous Emissions

Testing of the scrubber at its inlet and outlet was performed periodically during the test program using EPA Standard Methods. This was carried out to validate the results obtained from the continuous monitoring instruments. Table 4-2 summarizes the comparative data obtained in this manner. More detailed information appears in Appendix D.

4.1.4 Instrument Calibration

All analyzers were calibrated daily in the manner specified by the manufacturer of the instrument. Calibration gas was stored in the rear of the York Research Corporation Monitoring trailer and was injected at specifically controlled rates from the master control panel located within the trailer proper.

In addition to the standard calibration methodology, the calibration gas was injected up an auxiliary sample carrying line into the probe and then returned to the analyzers through the usual passageways. Utilizing this method, York engineers could determine if probe or sample line leakage existed.

As a final check on the instruments, York Research performed wet chemical testing under strict EPA guidelines. Samples were taken simultaneously at the inlet position and the trailer's analyzer lead-in, and then again at the outlet position and the trailer's analyzer lead-in. The following methods were used to verify instrumentation:

- Sulfur Dioxide: EPA Method #6
- Nitrogen Oxide: EPA Method #7
- Carbon Dioxide, Oxygen, and Carbon Monoxide: EPA Method #3.

TABLE 4-2. VALIDATION OF INSTRUMENTAL DATA

Parameter (Location)	No. of Tests	Avg. Concentration Manual	Instrumental
SO_2 (Inlet)	10	1028.8 ppm	1035.0 ppm
SO_2 (Outlet)	13	490.3 ppm	488.7 ppm
O_2 (Inlet)	2	6.3 %	6.4 %
O_2 (Outlet)	1	6.4 %	6.8 %
CO_2 (Inlet)	2	13.0 %	13.1 %
CO_2 (Outlet)	1	11.6 %	12.7 %

4.1.5 Operational Data

In addition to the test programs described, considerable attention was paid to the acquiring of operational data for the boiler, the electrostatic precipitator, and the scrubber. Logs similar to those compiled in the control rooms were kept by York Research personnel. These data obtained include:

- Boiler Load (MW)
- Steam Temperature
- Superheater Temperature
- Reheater Temperature
- Pulverizer Mill Outlet Flow
- Pulverizer Mill Temperature
- Burner Tilt Position
- Combustion Air Temperature
- Coal Feed Rate
- Supplemental Oil Rate
- Coal Composition

ESP

- Notivication of malfunctions

Scrubber

- Mist eliminator pressure drop

- Dryer draft
- Outlet temperature
- Product temperature
- Absorber pressure drop
- Inlet temperature
- Slurry temperature
- Circulation rate
- Centrifuge feed rate
- MgO slurry feed
- Recycle pump speed
- Centrifuge torque
- MgO tank level
- pH
- SO_2 inlet
- SO_2 outlet
- Induction fan speed

Each month a report was compiled containing the following:

- Statement of Program Progress
- Statement of Program Problems
- Discussion of data
- Raw emission data (Instrumental)
- Boiler operating parameters
- Scrubber operating parameters
- Chemical analysis of scrubber process streams
- Graphical representations of data and trends
- Daily log

This information is summarized in Appendix B (Hourly Data). A Daily Log of the unit's operation as well as the monitoring program is presented in Appendix C.

4.2 FGD System Availability

For the purposes of this evaluation, system availability has been defined as:

$$\text{Availability } (\%) = (t_o/t_p) \times 100$$

Where: t_o = Total hours system operated

t_p = Total hours in test program

Based upon data taken from the operating logs, the above relationship shows that the scrubber was available during approximately 48 percent of the test period. Availability includes all levels of operation; transient and steady-state alike. It is estimated that of the time the system was available, approximately 80 percent of that was steady-state where the system was operating normally.

There were several occasions in which one or the other of the two stages was operating separately. These are considered to be transient conditions. It should be noted that a portion of the outage time was due to lack of MgO supplies, as well as the fact that MgO slurry feed pumps were inadequate for handling full flow. The percent of availability then, could have been much higher had these deficiencies not existed.

4.3 Boiler and ESP Availability

Oxygen and carbon dioxide levels were constantly recorded at the scrubber inlet as indicators of boiler operating status and/or leaks in the ductwork (which would affect SO_2 concentrations in the flue gas). The levels of these two constituents remained very constant throughout the test program. This was due to the use of the excess O_2 monitor located in the plant control room which allowed operators to regulate the level of O_2 in the boiler within tight limits (generally 3-4 percent). The boiler availability was good during the test program. The boiler ran at varied loads due to changes in demand or operation, but for most of the program it was in the range of full load.

The ESP also operated smoothly. There are few records in the operator's log of any ESP shut-down or upset during the test period. All of the flue gas from Unit No. 3 passed through the ESP before entering the first stage of the scrubber. A duct to by-pass the ESP was

constructed, but this feature was very rarely used because very heavy grain loading was considered to be a strain on the demonstration unit's hardware. This type of operation was restricted to a few demonstrations.

5.0 TEST RESULTS

5.1 Boiler and ESP

The scrubber was designed to perform under a variety of boiler operating levels, and in practice it did this well. Unit No. 3 had a good performance record. Table 5-1 presents the operating parameters of the boiler.

5.2 Scrubber: Steady-State Operation

During the test program, the scrubber handled greater than 100 percent of the design flow on several occasions, but for the most part it ranged between 50 percent and 90 percent of its design capacity. On occasions when the boiler load was reduced because of wet coal or a loss of coal feeders, the scrubber seemingly operated independently of this reduction. The only effect was a drop in the SO_2 inlet concentration of approximately 200 ppm (or 15 percent). The second stage slurry pH values rose slowly in this case, and the MgO feed rate was lessened to compensate. Otherwise, this drop in load would not notably effect the scrubber.

The particle removal efficiency of the scrubber without the ESP preceeding it ranged between 99.2-99.7 percent. With the ESP in line, the scrubber's particle removal efficiency was between 94.1-99.5 percent.

5.2.1 Scrubber First Stage

Flue gas entered the first stage from the air preheater. Table 5-2 lists the ranges for the operation and chemical analyses performed on this stage.

TABLE 5-1. BOILER OPERATING PARAMETERS

Parameter	Range	Average
Load MW (gross)	88-190	
Average Capacity Factor		81
Burner Tilt (degrees off vertical)	+12 to -8	
Superheater Steam Flow (lbs/hr)		1,300,000
Flue Gas Temperature (^{o}F)		259
Flue Gas Flow Rate (ACFM) (full load)		590,000
Excess Oxygen (%)	3-4	
Combustion Air Temperature (^{o}F)	510-585	
Coal Consumption (tons/hr)		74.5
Heat Input (10^{6} Btu/hr)		1744
Coal Composition		
Heat Content (Btu/hr)	10,100-12,600	11,000
Sulfur (%)	1.20-3.30	1.74
Carbon (%)	59.0-72.90	66.6
Nitrogen (%)	0.87-1.50	1.30
Oxygen (%)	2.7-9.50	5.35
Hydrogen (%)	3.4-4.8	3.89
Ash (%)	13.8-21.7	17.2
Moisture (%)	0.4-2.5	1.3
Flue Gas Composition (inlet to scrubber)		
Oxygen (%)	5.0-10.0	
Carbon Dioxide (%)	11.0-17.0	
Nitrogen Oxides (ppm)	340-520	
Sulfur Dioxide (ppm)	660-1680	
Moisture (%)	5.1-8.7	
Grain Loading (ESP on) (gr/SCF)	0.09-0.25	0.3
Grain Loading (ESP off) (gr/SCF)	2.60-4.40	3.0
Duct Temperature (^{o}F)		240

TABLE 5-2. SCRUBBER FIRST STAGE OPERATING PARAMETERS

Parameter	Minimum	Maximum	Avg.
Inlet Gas Temperature (^{O}F)	250	265	
Inlet Gas Flow (ACFM)	100,000	300,000	
First Stage Pressure Drop (inches H_2O)	11.4	12.5	
Mist Eliminator Pressure (inches H_2O)	0.1	1.3	
Recycle Rate (gpm)	2850	3100	
Bleed Rate (gpm)			980
Compositions			
First Stage Bleed			
pH	1.1	6.1	
Suspended Solids (mg/l)	< 0.5	966	
Magnesium (mg/l)	11.8	113.9	
Chloride (mg/l)	7.5	2550	
Sulfite (mg/l)	0.1	0.5	
Sulfate (mg/l)	35.0	4340	
Thickener Overflow			
Recycle Line (gpm)			20
Suspended Solids (mg/l)	< 0.5	317	
Suspended Solids Removal Efficiency(%)	8.2	83.9	
pH	1.1	6.4	
Chloride (mg/l)	7.5	2550	
Thickener Underflow			
Suspended Solids (mg/l)	< 0.5	376	
Suspended Solids Removal Efficiency(%)	1.6	93.0	
pH	1.3	6.3	
Chloride (mg/l)	11.0	2550	

TABLE 5-2. SCRUBBER FIRST STAGE OPERATING PARAMETERS (CONT.)

Parameter	Minimum	Maximum	Avg.
Particle Removal Efficiency			
With ESP in line (%)	94.1	99.5	
Without ESP in line (%)	99.2	99.7	
Sulfur Oxides Removal Efficiencies (%)	5.0	10.0	

5.2.2 First Stage Bleed

The first stage bleed was the liquid sent to the thickeners for clarification after being circulated through the venturi throat along with the flue gas and had impacted the solid particulate matter. The samples were collected at the distribution box where the liquid from the bleed line was separated. The parameters determined were chosen to characterize the first stage recycle liquid for corrosiveness and to determine the amount of spill-over from the second stage absorber.

A pH as high as 6.1 occurred when a very light gas flow passed through the inlet. The pH always dropped with the length of time the scrubber was in operation because of the formation of acids (sulfuric, sulfurous, hydrochloric and some nitric from the absorption of gases in the water). An equilibrium pH value of 1.1-1.4 was reached after the longest run for which these data were obtained (84½ hours).

In order to determine if there was any cross-over contamination from the second stage's scrubbing water to that of the first, testing was performed to determine the magnesium ion (Mg^{++}) concentrations in the first stage. The Mg^{++} levels in the first stage bleed ranged between 11.8-113.9 mg/l. Contributors could have been the make-up water, the flyash, or contamination from the second stage. It seems that the make-up water was the most likely source of Mg^{++} in view of the magnitude of the maximum (113.9 mg/l). When tested in August 1974, the make-up water indicated levels of Mg^{++} ranging between 71.0-102.6 mg/l. Any reasonable increase in the Mg^{++} concentration over these values could be attributed to the recycling of the process water through the first stage.

The suspended solids level in this bleed line was a measure of thickener efficiency. Naturally, the level was low shortly after start-up, but rose to a high of nearly 1000 mg/l as operation was continued. As the thickener achieved an equilibrium operating state, the suspended solids level would drop from this maximum.

The presence of chloride and its associated corrosion problems was also investigated. The chloride ion concentrations were generally quite high, because the liquid was recycled, and the levels would increase as scrubber operating time increased.

The coal tested during a baseline study showed a chloride content of between 0.03-0.14 percent. Undoubtedly this was the primary origin of this ion in this first stage recycle bleed liquid, as it was absorbed from the flue gas or flyash. It is unlikely that this chloride level could have been introduced from the river water used for make-up because other parameters which were measured in this make-up water were very low. The iron, sodium, copper, mercury, phosphate and fluoride, when tested earlier were present in quantities low enough for the river water to be considered a relatively non-polluted surface water. The resulting corrosiveness could have been responsible for the occurrence of leaks in the first stage piping. Sections 6.0 and 7.0, and Appendix F describe these in detail.

The levels of $SO_2^=$ (sulfite) and $SO_4^=$ (sulfate) were approximately those which would be expected. They originated from the minimal absorption of sulfur oxides from the flue gas into the first stage liquid. Previous testing had shown that the concentration of SO_3 in the flue gas ranged between 0 and 55 ppm. SO_2 levels averaged about 1000 ppm in the stack gas. The first stage of the scrubber normally removed between 5 and 10 percent of the SO_2 in the flue gas, which formed sulfuric acid as it

dissolved in the liquid. The highest level of $SO_4^{=}$ measured was 3738 mg/l which is equivalent to a 0.1 normal sulfuric acid solution.

Thus the corrosive nature of this recycling bleed was established, and was considered to be sufficiently high to breakdown even No. 316 stainless steel. (R. Glenn, Weekly Technical Report, January 27, 1975).

5.2.3 Thickener Overflow

The thickener overflow was the clarified water from the thickener tanks. After being mixed with make-up water, this overflow was returned to the scrubber first stage. Make-up water was added to the system to replace that portion of the liquid going into the thickener underflow, and that lost due to evaporation.

Testing of this stream was done to determine the levels of suspended solids, chloride ion, and pH. The suspended solids remained in a range which indicated an adequate performance of solids removal by the thickener system. When the first stage recycling system reached equilibrium, the solids in the overflow ranged between 20-80 percent of the suspended solids level in the bleed line. The pH and chloride ion levels paralleled those of the first stage bleed as these concentrations were unaffected by the addition of flocculant to the liquid, or settling.

5.2.4 Thickener Underflow

This stream was the slurry product of the thickener flocculation process. The slurry was pumped to a transfer tank, and thence to a series of settling ponds. The water from the settling ponds was subsequently used to dilute the thickener underflow slurry in the transfer tank. Suspended solids, chloride ion levels, and pH were generally similar to those of the overflow samples. The efficiency of the thickener was minimal at low solids

concentrations (1.6 percent); however, it increased to a high of 93.0 percent removal when the incoming slurry (first stage bleed) had a high suspended solids content.

More definitive observations could have been made if the duration of periods of scrubber operation had been longer during this study of the first stage. Chloride concentrations were still climbing when the scrubber shut down due to a build up of product in the dryer. Other trends in solids removal may have become more evident during a longer operating period.

5.2.5 Scrubber Second Stage

After passing through the mist eliminators the gas was processed in the MgO absorber of the second stage. The dryer off-gas was also scrubbed in this section to remove any sulfur oxides and other pollutants generated from the oil combusted to heat the dryer. Table 5-3 lists the operating ranges of the various parts of this stage.

TABLE 5-3. SCRUBBER SECOND STAGE OPERATING PARAMETERS.

Parameter	Minimum	Maximum	Average
Inlet Gas Temperature (^{o}F)	110	120	
MgO Storage Silo capacity (tons)			100
MgO Belt feed rate (#/min)	15	25	
% MgO	85.0	96.2	90.1
% $MgSO_4$	0.01	12.57	2.75
MgO Slurry feed rate (gpm)	6	25	
MgO Slurry temperature (^{o}F)	120	165	
Pressure Drop total (inches H_2O)	0.4	13.0	
-absorber (inches H_2O)	0.4	4.0	
-mist eliminator (inches H_2O)	0.1	1.0	
Absorber circulation rate (gpm)	4600	5500	
Second Stage Bleed rate (gpm)			170
Second Stage Bleed Composition			
pH	5.5	8.0	
$MgSO_3 \cdot 6H_2O$ (%)	0.07	11.74	
Suspended Solids (%)	0.16	19.79	
$SO_4^{=}$ (filtrate)(%)	0.5	22.1	
MgO in solids (%)	0.06	41.86	
Density (g/ml)	0.99	1.34	
Outlet Gas Flow (ACFM)*	81,800	159,000	
Outlet Gas Composition			
Particulate (gr/SCF @ 12% CO_2)	0.0009	0.020	
O_2 (%)	5.0	10.0	
CO_2 (%)	10.4	16.0	

*Includes dryer off gas flow, which is added into Second Stage

TABLE 5-3. SCRUBBER SECOND STAGE OPERATING PARAMETERS (CONT.)

Parameter	Minimum	Maximum	Average
SO_2 (ppm)	63	350	
NO_x (ppm)	320	450	
Moisture (%)	7.5	13.0	
Outlet temperature (^oF)	111	145	
SO_2 Removal Efficiency (%)	61.0	93.0	
Centrifuge feed rate (gpm)	90	132	
Centrifuge Cake Composition			
Density (g/ml)	1.00	1.60	
Combined Water (%)	42.0	47.0	
Free Water (%)	7.0	15.0	
$MgSO_3$ (%)	40.0	45.0	
$MgSO_4$ (%)	3.0	6.0	
MgO (%)	0.75	7.0	
Mother Liquor Composition			
Solids (%)	0.08	12.62	
$MgSO_3 \cdot 6H_2O$ (%)	0.16	11.58	
MgO (% in solids)	0.20	21.96	
MgO (% total)	0.01	4.05	
Density (g/ml)	1.01	1.34	
Dryer Outlet temperature (^oF)	200	450	
Dryer Product composition			
Water (%)	0.2	15.0	
$MgSO_3$ (%)	60.0	75.0	

TABLE 5-3. SCRUBBER SECOND STAGE OPERATING PARAMETERS (CONT.)

Parameter	Minimum	Maximum	Average
Dryer Product Composition (Cont.)			
$MgSO_4$ (%)	5.0	10.0	
MgO (%)	2.0	10.0	
Density (g/ml)	0.45	0.70	
$MgSO_3$ Silo Storage capacity (tons)			200

5.2.6 The MgO slurry was prepared by mixing a weighed amount of MgO from the storage silo with the mother liquor from the centrifuge. The weigh feeder belt delivered between 15 and 25 lb./min. of MgO. The accuracy of this belt was not as dependable as was expected. This made the addition of MgO slurry into the scrubber difficult and caused a problem for the operators who were attempting to regulate the pH by this method.

During October, 1974, 200 tons of MgO were used. This was a mixture of virgin and regenerated MgO in a ratio of approximately 1.5:1. In November, 73 tons of additional virgin MgO were added to the silo. The rest of that month the scrubber operated using regenerated MgO. Later in December and January, some small quantities of virgin MgO were added to the silo to replenish the MgO that was lost in operation and in transportation.

Throughout the test program, the MgO was analyzed for $MgSO_4$ and MgO content. The samples ranged between 85.0-96.2 percent MgO and 0.01-12.57 percent $MgSO_4$.

The amount of MgO indicated the purity of the product used. No specific analyses for impurities were performed by York Research chemists, however, so the percent difference between the total of the percent MgO and percent $MgSO_4$ from

100 percent was assumed to provide the amount of foreign material present. These impurities could have originated from the flyash which was carried through the system into the second stage, or from corrosion and/or erosion products in the scrubber itself. Since this product was effectively recycled, these impurities increased with each absorption-recalcination cycle. Ultimately, these impurities could have reduced the reactivity of the MgO so as to render it useless.

The MgO slurry was mixed with the mother liquor and heated by a steam sparger. The slurry was then pumped into the second stage nozzles above the venturi. The stack gas and the MgO slurry proceeded through the venturi together. The scrubbed gas flowed through the mist eliminators to the scrubber outlet and the stack. The slurry dropped to the bottom of the second stage and was recycled through this process.

5.2.7 Second Stage Bleed

A small portion of the slurry containing unreacted MgO and the product $MgSO_3$ was bled off at a rate of 120 gpm and processed in the centrifuge. Make-up water was added to the absorber to maintain the proper consistency of the slurry. Fresh MgO slurry was added at a rate regulated by the operator to adjust pH. An ideal pH was between 6.8-7.2, because this range maximized the SO_2 absorption process without producing a build-up of crystals in the absorber. This also assisted the centrifuge and dryer to attain optimum performance. However, due to the difficulty in regulating the pH by MgO addition, normal operation included pH values ranging from 5.5 to greater than 8.0.

The lower pH values were indicative of problems that developed in the MgO slurry feed or recycle systems. These problems had the effect of reducing the amount

of MgO being pumped into the scrubber to a level that was lower than that required to react with most of the SO_2 present. The presence of excess SO_2 increased the acidity of the slurry. When the pH was allowed to drop below 6.8, corrosion of ductwork and piping could have become acute. The higher values occurred shortly after the scrubber startup, before the SO_2 in the stack gas had been thoroughly mixed with the absorbent MgO slurry. At this time the pH was as high as 9.4.

The solids content of this bleed slurry ranged between 0.16-19.79 percent. The different levels were due to changes in the MgO slurry feed rates, and the variations in flue gas flow into the scrubber. Both of these rates were manually set by the scrubber operators. The low values represented the initial operation shortly after the start up when the scrubber operated with reduced gas flow from the boiler. Values ranging from 3-8 percent were typical of favorable MgO feed rates and a proper pH level in the absorber slurry. Solids above 18 percent were not desirable because the pumping system from the absorber to the centrifuge could not adequately handle the crystals in the absorber slurry which forced the gas load to be reduced until the crystals could be freed.

The composition of these solids was studied to determine the amount of product ($MgSO_3$) formed in the absorber. Naturally, the higher this percentage, the more efficient the operation. The range for the test program was 0.07-11.74 percent $MgSO_3$. Another component of the solid portion of this slurry was MgO (range 0.09-19.6 percent). The difference was composed of impurities and insoluble sulfates.

The slurry density was also measured. This measurement gave a rough indication of the type of slurry that was introduced to the centrifuge. Operational changes could have been made using this parameter to obtain a more con-

sistent product and reduced wear on the system.

5.2.8 Centrifuge Cake

The slurry was introduced to the centrifuge to separate the solid and liquid portions. The centrifuge cake (solid portion) was analyzed to determine the character of the product. The bulk density was measured to indicate the free water in the cake. As the percent water increased the density decreased, which meant that the centrifuge efficiency had decreased. A very wet cake put a strain on the screw conveyor and dryer.

During August, the amount of free water was as high as 29.8 percent. The chemical analysis of the cake was comparable to past cakes; therefore, the cause of the high water content was possibly due to centrifuge performance. The centrifuge weir heights, which controlled the degree of liquid/solid separation, were adjusted during the August 26, 1975 outage but no chemical analyses were performed after this date to determine if the centrifuge was the problem.

The percent MgO was measured to determine the amount of unused reactant leaving the absorber. Low MgO concentrations (less than 3 percent) reflected good absorption in the second stage. High values (above 6 percent) reflected a high pH in the absorber, low gas flow, low reactivity of the MgO, or decreased slaking due to failure of the steam lines to the MgO slurry make-up tank at certain times.

5.2.9 Mother Liquor

The liquid separated by the centrifuge was returned to the process to be recycled. Most of it was pumped directly into the second stage of the scrubber below the venturi. A small portion was used with the MgO to make up the MgO slurry.

The solids concentration in this liquor varied inversely with the efficiency of the centrifuge. A determination of the reacted product $MgSO_3$ was made to observe the amount that was recycled. The percent MgO was also monitored. High MgO readings may have resulted from a high second stage pH, unreactive MgO, or decreased slaking in the MgO slurry tank.

5.2.10 Dryer Product

The dryer prepared the centrifuge cake for storage and shipment to the calcination facility. Final composition analyses were performed on this product. Water content ranged between 0.2-15.0 percent. $MgSO_3$ content was normally within 60-75 percent and the unreacted MgO levels were between 2.0-10.0 percent.

The percent MgO in the dryer product was analyzed in order to determine how much unreacted material was being carried through the system and being shipped out for regeneration. A low percent MgO reading was desirable because it reflected good SO_2 absorption and economical operation of the system. Among the factors that may have effected high MgO readings are a high pH in the second stage slurry, unreactive MgO, and decreased slaking due to failure of steam lines to the MgO make-up tank. Variations in MgO content could be attributed to pH fluctuations in the absorber, changes in the volume of flue gas processed, the type of coal burned, the percent of MgO in the slurry, and centrifuge efficiency.

The bulk density of the dryer product was measured as an indication of the character of the product. This would have been an aid in determining the volumes and weights of the product for shipment and bucket elevator performance.

In January 1975, a high percentage of H_2O in the dryer product was deliberately induced in order to determine the effect of percent H_2O on the bulk density. It was

found that increased in H_2O did increase the bulk density. This was significant because shipping and handling costs could definitely be affected by the moisture content of the dryer product.

A question was raised regarding the iron content of the system. All of the existing pipes leading from the second stage back to the dryer system were composed of carbon steel. After a lengthy outage, October 26 to November 10, 1974, the iron content of the system was measured by analysis on the dryer product solids at two-hour intervals. Upon start-up, the iron in the first dryer product sample was determined to be 3.77 percent Fe_2O_3. Within a twentyfour-hour running period, the iron content diminished to the 200 ppm (0.2%) Fe_2O_3 and held constant at that level for a sustained period. The results are plotted in Figure 5-1.

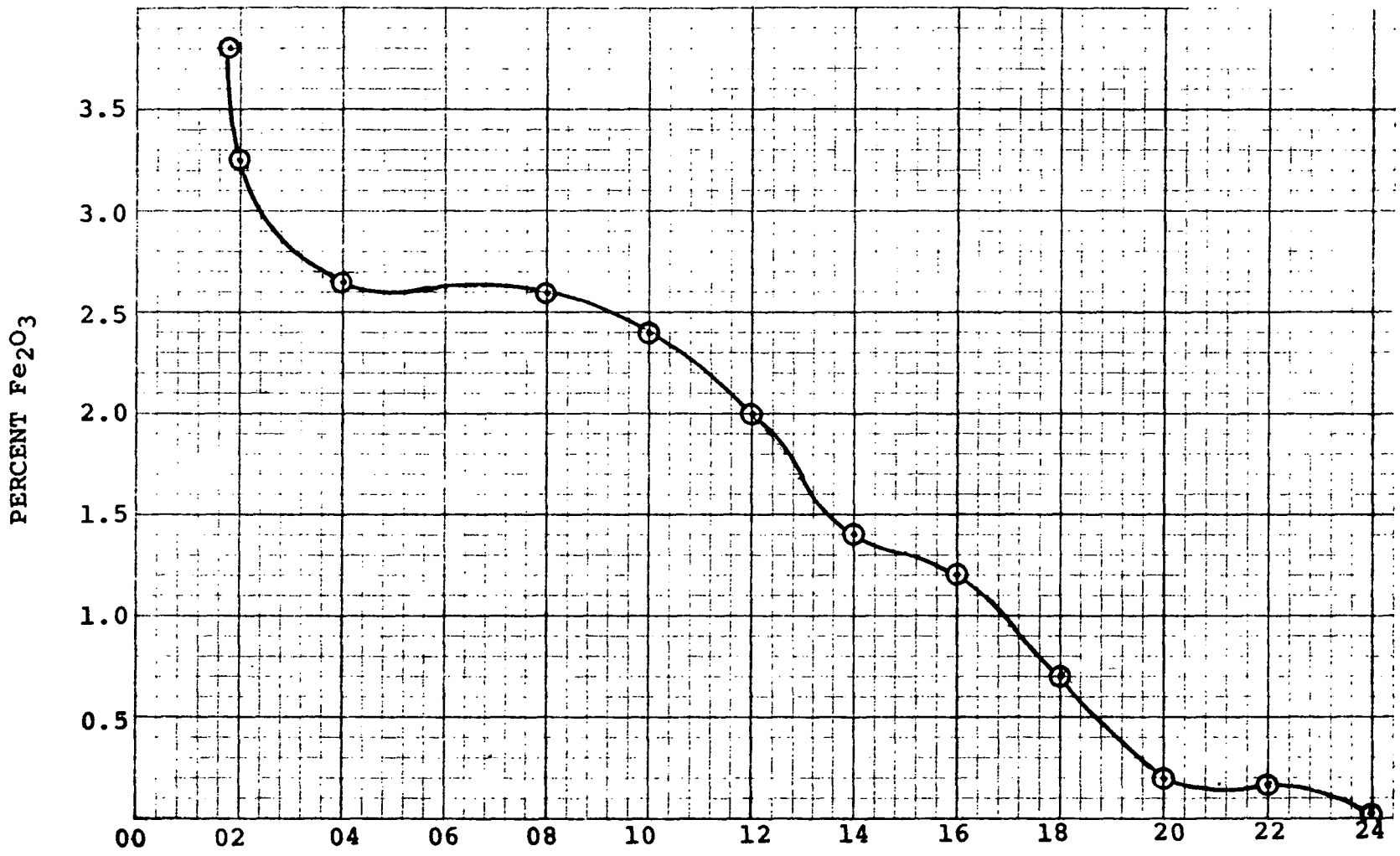
Chloride concentration in the coal was found to be 0.02-0.20 percent at this time. Chlorine from the coal combustion forms HCl gas which reacts with the MgO (aq.) forming soluble $MgCl_2$. It was believed that the $Cl^-(MgCl_2)$ concentration continually increased with on-line time since the soluble $MgCl_2$ was circulated through the system continually via the mother liquor.

5.3 Scrubber: Transient Operation

Transient operation occurred during scrubber start-ups, shut-downs and malfunctions. The major point of interest in the documentation of these conditions was their effect on emissions.

5.3.1 Start-Ups

Before starting the scrubber induced draft fan (ID), it was necessary to prepare the scrubber to receive stack gas. The MgO slurry for use in the second stage of the



DRYER PRODUCT Fe_2O_3 (11/10/74)

FIGURE 5-1

scrubber was mixed in the slurry make-up tank. This slurry was then pumped in and circulated through the second stage. First stage liquid, which was a combination of the thickener overflow liquid and make-up water, was also circulated through the scrubber. As the scrubber ID fan was started, dampers on the inlet and outlet to the scrubber were opened, allowing the stack gas to circulate. When a sufficient amount of $MgSO_3$ crystals had formed in the second stage, the centrifuge, dryer, and solids handling equipment were placed in service.

Within a few minutes the SO_2 removal efficiency was typically 70-80 percent. Additional information on SO_2 concentration and percent SO_2 removal during several start-ups is included in Appendix E.

5.3.2 Shut-Downs

Prior to stopping gas flow to the scrubber, SO_2 removal efficiencies were observed between 70-80 percent. Table 5-4 shows typical shutdown data. More detailed information is presented in Appendix E.

5.3.3 Malfunctions

Table 5-5 summarizes the overall effect of several major transient conditions. Generally, if equipment failure caused shutdown of major components such as the centrifuge, or required major changes in liquid or gas flows, then SO_2 removal was significantly reduced.

Generally, many of the malfunctions, and the leaks discussed in the following Section, were attributable to the delivery of off-specification pipe and fittings during construction, and to the use of off-specification nuts, bolts, hanger rods, and nozzles. In addition, in some cases, stainless steel was of an improper grade, and rubber linings were too thin and poorly bonded.

TABLE 5-4. PERCENT SO_2 REMOVAL AT SHUTDOWN.

Date	Time	Boiler Load (MW)	Scrubber ΔP 2nd Stage (in. H_2O)	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency (%)
11/11/74	0145			6.0		220	78.0
	0200		1.0		1175		
	0215					250	78.7
	0230		0.0	5.6	1200		
	0245					1200	0.0
11/16/74	2045					210	79.0
	2100			7.4	1000		
	2115					210	79.0
	2135		0.0		1000		
	2145					1000	0.0
	0800	140	8.0	7.0	880	160	81.8
12/23/74	0900	169	6.2	7.2	860	160	81.4
	0930	-	-	-	-	-	0.0
	1900	188		7.1		185	
	1915				920		80.2
11/12/75	1930					150	
	1945				900		83.3
	2000	185		7.0		OFF SCALE	
	0730		4.9		900		
	0745		6.8			190	78.9
11/24/75	0800	147	5.5	7.3	900		
	0815		6.4			190	78.9
	0830		0.0		850		
	0845					850	0.0

TABLE 5-5. SUMMARY OF MAJOR TRANSIENT CONDITIONS

Condition	Time of Transient Condition	Previous* 2nd Stage Δp	Transient Condition Δp	Previous* SO_2 Outlet(ppm)	Transient Condition SO_2 Outlet (ppm)	Previous* % SO_2 Removal Eff.	Transient Condition % SO_2 Removal Eff.	
Centrifuge Repair - Cover leak erosion of carbon steel	11/15 1000-1500	8.0	4.1	125	175	85.6	75.9	Slurry feed flow rate had to be reduced and scrubber init could not handle design gas flow. Un treated portion was by passed to stack
Centrifuge Diversion-Maintenance procedure - wash out the chute	0430-0515 1/14	NA	NA	160	160	84.0	84.3	
Centrifuge Diversion - Clogged hopper-wet centrifuge cake, possibly due to improper weir height	0100-0145 12/28	NA	NA	80	70	90.9	91.9	
1st Stage Outage - Leak - 1st Stage recycle lines. Breaks in rubber lining exposed carbon steel pipe to low pH/ high abrasive content liquid of 1st Stage	1200-1250 12/7	9.3	3.0	169	230	80.9	74.2	Scrubber unit could not handle design flow. Untreated portion was bypassed to stack
2nd Stage Outage - Leak in discharge header-abrasive action of the solids laden slurry	1300-1400 12/16	6.2	0.0	168	683	82.2	23.1	
2nd Stage outage-Repair recycle header-20" pipe very thin due to abrasive action; holes easily formed	1000-1200 12/19	8.4	NA	206	300	82.1	75.0	
2nd Stage Outage	1900-2000 8/26	3.4	0.8	302	1075	73.2	4.4	

* Refers to steady-state conditions in existence prior to the transient condition.

TABLE 5-5. SUMMARY OF MAJOR TRANSIENT CONDITIONS (CONT).

Condition	Time of Transient Condition	Previous* 2nd Stage Δp	Transient Condition Δp	Previous* SO_2 Outlet (ppm)	Transient Condition SO_2 Outlet (ppm)	Previous* % SO_2 Removal Eff.	Transient Condition % SO_2 Removal Eff.	
Boiler load was reduced-Wet coal-high surface moisture reduced pulverized mill outlet temperatures to below the 150°F minimum needed to maintain an adequate drying cake.	1500-0800 12/8-12/9	8.5	4.1	143	273	85.4	75.3	Gas flow through the scrubber was reduced and SO_2 emissions were used under the period.
Rising Boiler Load - Partial alleviation of wet coal problem	0900-2400 12/9	4.1	5.4	273	207	75.3	77.6	
Coal feed problem required reduced boiler load - Wet coal - agglomeration of coal particles before the pulverizer	2300-2000 12/20-12/21	6.2	3.6	232	232	81.7	78.2	

* Refers to steady-state conditions in existence prior to the transient condition.

The scrubber's absorption efficiency was not unusually sensitive to gas flow because the venturi design provided greater than 70 percent of SO_2 removal even though Δp was reduced by 50 percent and gas flow was 70 percent of the normal rate.

5.3.4 Leaks

Table 5-6 details the frequency with which individual leaks occurred. Apparently there were twice as many leaks causing shutdown in the first stage of the scrubber as in the second stage. The rubber-lined pipes in the first stage sustained more mechanical damage because they were subjected to extraneous material (such as pieces of weld), which might have been carried in with the flue gas. In addition, extensive corrosion and erosion were noted from tests performed. Both chemical and visual observations to this affect were performed.

5.3.5 Centrifuge Outages

Approximately 1.6 percent of the total recycle of the second stage was taken from the discharge of the recycle pumps to the centrifuge. The centrifuge normally removed 50 percent of the solids in this liquid stream. During the course of the scrubber study, the centrifuge had to be diverted numerous times because of clogging or leaks that developed in its cover. Consequently, no solids were removed during these periods.

TABLE 5-6.

LEAKS NOV., DEC. '74; JAN., AUG. '75

Affected Component	Occurrences	Number Inducing Shutdown	Duration of Outage
First stage bleed line	7	3	150 hrs.
First stage recycle lines	9	4	153*
First stage headers	6	1	41 hrs.
"A" 1st stage pump	2	2	½ hr.
Reducer, Nozzle lines, and pump	4		
Second stage bleed lines	1	1	66 hrs.
Second stage recycle line	2	1	28 hrs.
Second stage discharge headers	5	1	2½ hrs.
Second stage drain connection	1	1	81 hrs.
"B" discharge pump	1	1	2 hrs.
Centrifuge Cover	9	1	

* This excludes a 14 day outage begun August 27, 1975 to replace the lines.

The effect of a typical centrifuge malfunction requiring shutdown for repair is summarized below:

TABLE 5-7. CENTRIFUGE REPAIR

Condition	Second Stage Δp	pH	SO_2 Outlet Concentration (ppm)	SO_2 Removal Efficiency (%)
Steady-State Condition Before the Centrifuge Repair (0400-0900,11/15)	8.0	7.5	125	85.6
Centrifuge Repair (1000-1500,11/15)	4.1	7.0	275	75.9

Centrifuge shutdown occurred at 0940. To prevent build-up of excess solids, gas flow to the unit was reduced at 1000. It was further reduced at 1030 when no progress was made on the repair. The second stage Δp had been 8.0 inches of water. As a result of the reduced gas flow and Δp of 4 inches, SO_2 removal efficiency dropped from 85.6% to 75.0%. It eventually bottomed at 73.8% removal, but because of continued reduced gas flow, it did not stabilize until 1500 hours when the removal efficiency averaged 78.9%.

Increased liquid/gas ratio somewhat off-set reduced gas velocity through venturi yielding a somewhat lower SO_2 removal efficiency during the repair period. The lower pre-repair levels of SO_2 outlet emission were reached a few hours later. Lower gas flows were continued beyond the return of the centrifuge to operation so a reduction in the accumulated solids might be effected. Excessive solids build-up in the system placed undue strain on pumps and increased erosion. When a problem with the centrifuge required a diversion, gas flow to the unit was reduced before and during the outage to reduce solids build-up.

MgO slurry feed was reduced and the lessened gas flow continued until accumulated solids had been separated as shown below:

TABLE 5-8. CENTRIFUGE PERFORMANCE

Time	Second Stage Bleed (% Solids)	Mother Liquor (% Solids)
0800	6.9	1.16
1200	8.25	3.99
1600	3.96	1.33

The result of the 2-hour and 40 minute outage was a 5½ hour period of higher than steady-state emissions. Although stability was attained at the end of this time period, emissions still had to fall to attain prior steady-state levels. It is concluded that continuous reliable centrifuge separation of solids is important to effective scrubber operation.

5.3.6 First Stage Outages

A leak of the first stage recycle lines on December 7, 1974 necessitated a complete first stage shutdown. The first stage was down for 50 minutes, from 1200 to 1250 hours. The effect is summarized in Table 5-9.

TABLE 5-9. FIRST STAGE OUTAGE

Condition	Comparison of Parameters: Second Stage Δp	Second Stage pH	SO_2 Outlet (ppm)	% SO_2 Removal Efficiency
Steady-State Period Prior to Outage (0100-1000,12/7)	9.3	7.1	169	80.9
First Stage Outage (1200-1250,12/7)	3.0	7.5	230	74.2

Gas flow to the FGD unit was reduced and efficiency of SO_2 removal was reduced. Additional data are presented in Appendix E.

5.3.7 Second Stage Outages

December 16, 1974 the second stage was shutdown at approximately 1255 to weld a leak in the discharge header. As shown in Table 5-10, gas flow to the scrubber was reduced and the second stage Δp, which had been 6.4 at 1200, dropped to zero. Efficiency decreased from 83 percent at 1200 to 23 percent at 1322, and stayed in the low 20's until start-up at 1510. This Table compares the parameters from the steady-state period prior to the outage with those of the transient condition.

TABLE 5-10. SECOND STAGE OUTAGE

Condition	Second Stage ΔP	pH	SO_2 Outlet Concentration (ppm)	% SO_2 Removal Efficiency
Steady-State Period Before Outage (0500-1200, 12/16)	6.2	7.2	168	82.2
Second Stage Outage (1300-1400, 12/16)	0.0	8.0	683	23.1

This is typical of the efficiency reduction associated with a second stage outage. Two other such outages occurred, and detailed data are presented in Appendix F.

6.0 ENGINEERING EVALUATION

Three primary goals can be outlined for the Magnesia FGD demonstration unit. The first goal was to construct and operate the system according to design specifications, for extended periods of time. The second goal was to study the sub-systems of the process and optimize their performance in order to optimize the over-all system performance. The third goal was to vary the flue gas composition and flow rate to the system and observe the overall system performance. The following engineering evaluation of the process is divided into these three sections. The sections discuss (1) the operability of the process as it was designed, (2) the optimization efforts undertaken, and (3) the over-all performance of the system.

6.1 Operability

The operability of the system is discussed separately for the first and second scrubber stages along with their individual sub-systems. These sections discuss the malfunctions, repairs, and maintenance performed during the test program. Appendix F lists each malfunction and the type of maintenance performed in chronological order. These data were compiled from the Chemico Operator's Log and from the Weekly Technical Reports prepared by Mr. Roland Glenn. The August 1975 listings in Appendix F are solely from Mr. Glenn's reports as no scrubber operator's log was available.

6.1.1 Scrubber System First Stage

Throughout the scrubber testing program, the system operation was hampered by malfunctions. A majority of

these malfunctions occurred in the first scrubbing stage due to leaks in the pipes, valve liners, and headers. The areas most vulnerable to leaks were areas where the flue gas changed direction within the scrubber or where rapid slurry velocity increases occurred in piping such as at elbows, reducers, and orifice plates. Rubber liners in the pipes and valves were torn and gouged by stray pieces of metal in the system. These breaks in the liner exposed the steel pipe to the highly corrosive liquid of the first stage. Table 6-1 is a compilation of the leaks encountered in the first and second stage during the periods of November and December, 1974, and January and August, 1975.

On January 18, 1975, after an inspection of the inside of the first stage vessel, it was reported that six of the ten tangential spray nozzles were missing. The probable cause of these stainless steel nozzle failures was the high concentrations of chlorides, low pH of the recycle slurry, and off-specification stainless steel. Chloride from the combustion of the coal in the boiler aided in the corrosion by pitting and etching the steel, exposing surface area to sulfuric acid attack. The pitting was more prevalent on the outside of the nozzle where acid mist had settled. The use of acid resistant coatings, rubber or plastic pipes and nozzles in this location should be considered.

Available data indicate that leaks adversely affected scrubber efficiency when the repair undertaken required alterations in scrubber operating parameters. A case in point was provided by the data of December 7, 1974 when a leak of the first stage discharge header caused the shutdown of the entire first stage.

TABLE 6-1. LEAKS OF THE SCRUBBER SYSTEM
Nov.,Dec.'74; Jan.,Aug.'75

Scrubber Component Affected	Occurrences	Number Inducing Shutdown	Emission Control Time Lost to Outages (Approx.)
First Stage bleed line	7	3	150 hrs.
First Stage recycle lines	9	4	489 hrs.*
First Stage discharge headers	6	1	41 hrs.
First Stage recycle pumps	2	2	½ hr.
First Stage piping reducers and nozzles	4		
Second Stage bleed lines	1	1	66 hrs.
Second Stage recycle line	2	1	28 hrs.
Second Stage discharge headers	5	1	2½ hrs.
Second Stage drain connection	1	1	81 hrs.
Second Stage recycle pumps	1	1	2 hrs.
Centrifuge cover	9	1	

* This includes a 14 day outage begun August 27, 1975 to replace the lines.

On this occasion, the first stage was down for 50 minutes, from 1200 to 1250 hours. The short duration permitted but one set of wet test readings for the outage which appear in Table 6-2. Also included are the average parameters for the steady-state period immediately before. The drop in efficiency induced by the first stage shutdown was approximately 7 percent. SO_2 outlet concentrations increased by 36 percent. Scrubber operators reduced inlet flows during the outage and the second stage pressure drop decreased. This, in turn, contributed to reduced performance. The pH was also affected by the lower gas flows. In this case it was a combination of lower flows and insufficient reduction in the MgO slurry feed rate that led to a higher pH reading.

Inspection of the demister in the first stage indicated

TABLE 6-2. FIRST STAGE OUTAGE
December 7, 1974

Condition	Comparison of Parameters: Inlet Flow ACFM*	Second Stage Δp	pH	SO_2 Outlet (ppm)	% SO_2 Removal Efficiency
Steady-State Period Prior to Outage (0100-1000,12/7)	230,000	9.3	7.1	169	80.9
First Stage Outage (1200-1250,12/7)	140,800	3.0	7.5	230	74.2

* At the inlet to the first scrubber stage.

that there was no problem with solids deposit formation. The principal problem with the demisters appeared to be from physical abuse from being walked on during inspections. There was no apparent reduction, however, in the performance of this equipment.

6.1.2 Solids Removal Section for the First Stage

Generally, there were few problems in the operation of the solids removal section of the first scrubber stage. This can be attributed to two operating conditions that existed during the test period. The first was the flue gas which came directly from the electrostatic precipitator the majority of the time. As a result there was not a very heavy load placed upon the solids removal equipment. The second condition that existed were dual particle removal systems which allowed each thickener to operate independently of the other. Consequently, there was only one instance where the solids removal equipment forced a shutdown of the scrubber system. This occurred on January 19, 1975 and was the result of a restriction in the first stage bleed line.

The thickener overflow and underflow were not sampled on a routine basis until August 1975. During August, the longest sustained operating period was 85.5 hours. Since complete test data are lacking, nothing more can be said about the operability of this section other than to note the few failures which occurred in the list of scrubber malfunctions in Appendix F.

6.1.3 Scrubber System Second Stage

Malfunctions in the absorber section of the second stage were not as numerous as those in the first stage where the pH was very low. Leaks in the second stage recirculation piping were caused by abrasion, where the solids in the slurry eroded and finally destroyed the piping. From thickness measurements made by Chemico personnel with an ultrasonic thickness measurement instrument on the second stage lines, the pipes showed excessive erosion on surfaces where maximum abrasion would be expected. These areas were primarily the elbows, reducers, and places where a change in flow direction occurred. The MgO slurry contained up to ten percent solids under normal operating conditions. This accounts for the abrasiveness

of the slurry, especially on unlined steel piping. Decreases in liquid velocities slowed this wear, but installing abrasion resistant rubber liners would have been more desirable.

There were three second stage outages during the scrubber study: December 16, 1974, December 19, 1974, and August 26, 1975. On December 16, 1974 the second stage was shut down at approximately 1255 to weld a leak in the discharge header. (The first stage was still operational). Scrubber inlet gas flow was reduced and second stage Δp, which had been 6.4" H_2O at 1200, dropped to zero. Efficiency decreased from 83 percent at 1322, and stayed in the low 20's range until startup at 1510. Table 6-3 compares the parameters from the steady-state period prior to the outage with those of the transient condition itself. The steady-state period was from 0500 to 1200 hours on 12/16.

During this outage the SO_2 removal efficiency remained at approximately 20 percent for an hour and 45 minutes after the second stage was off-line. Apparently, the MgO slurry remaining in the absorber without being circulated absorbed a small amount of SO_2 until the surface became saturated. Normally, the first stage removed between 5-10 percent of the SO_2 in the flue gas. This was measured when the second stage was not only inoperable but empty as well.

TABLE 6-3. SECOND STAGE OUTAGE
December 16, 1974

Condition	ACFM*	Second Stage Δp	Second Stage pH	SO_2 Outlet Concentration (ppm)	% SO_2 Removal Efficiency
Steady-State Period Before Outage (0500-1200,12/16)	146,000	6.2	7.2	168	82.2
Second Stage Outage (1300-1400,12/16)	74,800	0	8	683	23.1

* At the inlet to the first scrubber stage.

6.1.4 MgO Slaking and Recycle

The MgO slaking equipment used in preparing the MgO slurry operated relatively trouble free. The MgO belt experienced problems with slippage, but these were remedied by adjustments. The steam line to the MgO tank clogged once and the controller had one malfunction, but repairs were made without a shutdown. On August 11, 1975, a crack developed in the steam control valve. During the period when the steam line was not in use, a higher than normal amount of unreacted MgO was found in the second stage bleed. When the steam line was put back into use, the amount of unreacted MgO returned to normal. Further discussion of MgO slaking is covered in Section 6.2.2 where its effect on system optimization is illustrated. The two rubber lined pumps (one operating and one standby) used for MgO slurry transfer and recycle of the second stage slurry normally operated reliably. However, with one pump on the line it was not possible to maintain full design gas flow through the unit. In order to provide sufficient slurry at design gas flows and SO_2 loadings it was necessary to operate both pumps together.

Leaks in the pumps were generally remedied by repacking or adjusting the seals. The main problem experienced by the pump inlet and outlet lines was clogging because of an accumulation of MgO. This may be remedied by being able to isolate the individual pumps and lines when they are not in service. They could then be cleared through a series of wash-out valves. The cleaning of these pumps and lines could be part of a routine maintenance schedule.

6.1.5 Solids Removal Section for the Second Stage

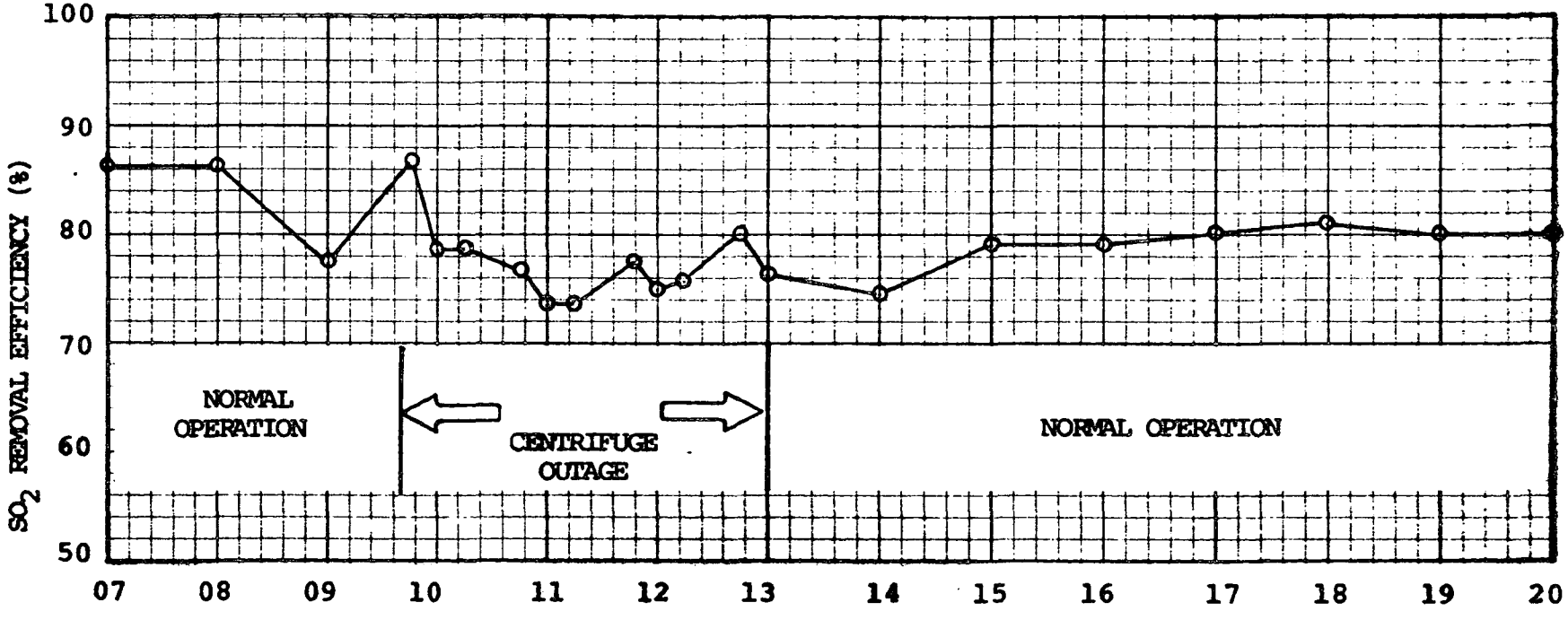
Centrifuge cover leaks and clogging of the centrifuge chute were the major problems with this equipment throughout the test program. The leaks in the cover were probably caused by the abrasive material in the centrifuge feed water which wore away the carbon steel. The centrifuge chute required almost continual attention at times, depending on the consistency of the centrifuge cake. On days when the cake was wet or sticky, the chute would require periodic cleaning during each shift in order to prevent clogging. The angle of the chute was changed once during the program and the vibrators were adjusted for continual operation but these changes had little effect on the clogging problem. As the test program progressed, The operators started to wash the chute on a regular basis during their shift to prevent this problem. Using a different configuration or type of equipment may eliminate these problems in future designs.

Approximately 1.5 percent of the total recycle of the second stage was taken from the discharge of the recycle pumps to the centrifuge. The centrifuge normally removed 50 percent of the solids in this liquid stream. During the course of the scrubber study, the flow to the centrifuge had to be diverted numerous times due to clogging of the centrifuge chute at higher gas flow and SO_2 loading conditions. To initiate the assessment of the effects of these diversions, data taken during the centri-

fuge repair on 11/15 were plotted in Figure 6-1 when the centrifuge was out of service for about 2 hours and 40 minutes. The centrifuge shutdown occurred at 0940. To prevent build-up of excess solids, the scrubber operators reduced the gas flow to the unit at 1000. It was further reduced at 1030 when no progress was made on the repair. The accompanying data sheet (Table 6-4) displays the second stage Δp and inlet gas flow experienced during this outage. As a result of the operator action, SO_2 outlet levels jumped from 120 ppm at 0900 to 250 ppm by 1000, for a rise of over 100 percent. They eventually peaked at 340 ppm, but because of continued reduced gas flow, they did not stabilize until 1500. The lower pre-repair levels of SO_2 outlet emissions were reached several hours later.

Reduced gas flows were continued beyond the return of the centrifuge to operation so that a reduction in the solids that had accumulated might be affected. Excessive solids build-up on the system placed an undue strain on the pumps and exposed pipes to erosion. When a problem with the centrifuge necessitated diversion, operators attempted to circumvent the situation by first reducing the flow of gas to the unit before and during the outage to prevent solids build-up, and then by continuing this reduced gas flow afterwards to work down the accumulated solids. Along with the reduction in flow, the operators decreased the MgO slurry feed.

The centrifuge outage caused a reduction in SO_2 removal efficiency because of the need to reduce the gas flow as part of the remedial action. Thus the two hour and 40 minute outage also caused a substantial build-up of solids in the system, especially in the mother liquor, which normally received centrate directly from the centrifuge. This is illustrated in Table 6-5.



SO_2 REMOVAL EFFICIENCY DURING CENTRIFUGE OUTAGE (11/15/74)

FIGURE 6-1

TABLE 6-4. BOILER/SCRUBBER DATA (NOV. 15, 1974)

Time	Boiler Load (MW)	Scrubber Δp (2nd Stage)	Slurry pH	SO_2 (ppm) inlet/outlet	SO_2 Removal Efficiency (%)
0700			7.4	900/125	86.1
0800	169	8.0	7.4	900/125	86.1
0900			7.4	780/176	77.1
0930				-	-
0945				780/100	87.2
1000	180	5.8	6.4	1150/250	78.3
1015				1150/250	78.3
1030				-	-
1045				1450/340	76.6
1100			7.3	1300/340	73.8
1115				1300/340	73.8
1130				-	
1145				1200/270	77.5
1200	178	3.0	7.1	1100/275	75.0
1215				1100/265	75.9
1230				-	-
1245				1050/210	80.0
1300			7.3	1050/240	77.1
1400	178	3.0	7.0	1050/270	74.3
1500			7.1	900/190	78.9
1600	173	5.2	7.1	900/190	78.9
1700			7.0	900/180	80.0
1800	174	5.2	7.0	900/170	81.1
1900			7.2	800/160	80.0
2000	178	7.0	6.9	800/160	80.0

Centrifuge Outage

TABLE 6-5. PERCENT SOLIDS

Time	Second Stage Bleed (%)	Mother Liquor (%)
0800	6.9	1.16
1200	8.25	3.99
1600	3.96	1.13

The increase in solids measured in the mother liquor from 0800, which was before the centrifuge diversion, to 1200, was 240 percent. By 1600 hours that afternoon, or by 3½ hours after the centrifuge was back on line, the solids had been decreased to its previous level. In the case of the second stage bleed, the increase at 1200 was not quite as dramatic, but the solids were reduced by 50 percent by 1600.

Analysis of these results is somewhat hampered by the time lag between test measurements. If it had been possible to follow more closely the rapidity of solids build-up during the centrifuge outage, it might have been feasible to extrapolate relationships between duration of outage, extent of solids build-up, and minimum time necessary to work down accumulated solids. The four hour readings did not provide any continuous assessment.

The final result of the two hours and 40 minute centrifuge repair on 11/15, then, was a five and one-half hour period of higher than steady-state emissions. Although stability was attained at the end of the repair outage, the emission level took several more hours to return to thr prior steady-state concentration. This effect is shown in Table 6-6.

TABLE 6-6. CENTRIFUGE REPAIR

Condition	Average Parameters Second Stage Δp	pH	SO_2 Outlet Concentration (ppm)	% SO_2 Removal Efficiency
Steady-State Condition Before the centrifuge repair (0400-0900, 11/15)	8.0	7.5	125	85.6
Centrifuge Repair (1000-1500, 11/15)	4.1	7.0	275	75.9

Because of the centrifuge repair, SO_2 removal efficiency fell almost 10 percent, to 75.9 percent. Correspondingly, SO_2 outlet concentrations increased by 120 percent. The large drop in second stage Δp contributed substantially to the efficiency decrease. It should be noted, however, that second stage pH dropped from 7.5 to 7.0. This was due to a cutback in MgO slurry feed in order to curtail the accumulation of additional solids.

It is apparent that its capacity as a solid extractor makes the centrifuge important for effective scrubber operation. The exact time period the scrubber can operate without the centrifuge was not discernible from the data of 11/15/74.

Other malfunctions that occurred in the solids handling equipment were due primarily to centrifuge cake consistencies which interfered with the dryer, the screw conveyor and the bucket elevator operation. The dryer would clog when fed exceptionally wet cake; however, this problem would normally clear up if the centrifuge flow was diverted for a short time. On one occasion the scrubber was shut down because the dryer became so clogged it had to be cleared manually.

The bucket elevator operations were not always reliable during the project. An extremely wet or dry dryer product would cause the elevator to become ineffective. A wet product would overload the elevator and a very dry product would be dusty and difficult to handle. Buckets were changed once during the program, but became distorted and bent after a short time.

One final malfunction that occurred in the solids handling equipment concerned the dryer ID fan belts which burned out on November 12, 1974. When the belts were replaced, the fan would not start because of the water accumulated in the fan housing. After this incident the draining of this housing was performed regularly as a maintenance function. The water condensed and accumulated in this area whenever the dryer off gas temperature was below 212^{o}F.

6.1.6 Process Control

The process control of the scrubber system was relatively simple and thus created little problem in keeping the system functioning. The liquid flow rates through the scrubber were constant and independent of gas load. The MgO additive feed rate was varied to maintain the slurry pH at a preset point, about 7. The main problem in the control room was with the pH meter which measured the pH at the discharge of the second stage re-circulation pump. During the test program the pot for the meter developed leaks and had to be patched. In addition, the meter became plugged at times with crystals and had to be manually cleaned.

Other control equipment that required maintenance included the SO_2 analyzer probe which was replaced because it was badly eroded. Some of the flow rotometers froze and burst. These were replaced or bypassed with spool pieces, when replacements were not available. The MgO weigh feeder was also found to be inaccurate and had to be recalibrated.

Control dampers were installed as indicated in Figure 3-2 (Section 3 - Process Description) to regulate the amount of gas going through the scrubber. Throughout the test period of October, 1974 to September, 1975, the dampers were frozen in position. This left the ID fan after the scrubber as the only control device for varying the gas flow rate through the scrubber system.

6.2 Optimization

In order to properly optimize the individual components within the process, the system should have been capable of operating at steady-state conditions for extended periods of time. As can be seen from the previous section on operability, steady-state conditions were not attainable for very long periods during the study. The system was operated for a maximum duration of 120 hours before a shutdown was required due to equipment malfunctions. However, several attempts were made throughout the study to try and optimize various components within the system.

Discussion of the optimization efforts of the FGD process centers on the second stage of the system. Except for problems with materials of construction, the first stage of the scrubber performed very well during the testing program. As a result no efforts were made to optimize the components of the first stage.

6.2.1 Second Stage Absorber

To provide a better assessment of the influence of certain operating parameters, experiments were conducted at Dickerson modifying selected parameters and recording the results. The first operating parameter to be changed was the re-circulated liquid flow rate to the tangential sprays and cones of the second stage. These experiments were conducted on the 14th and 17th of December, 1974. Data collected for the variation of liquid flow rate appear in Tables 6-7 and 6-8.

TABLE 6-7. BOILER/SCRUBBER DATA

Date: 14 December 74 Time Span: 1400-1500 Test Condition: Variance of Liquid Flow Rates

Time	Boiler Load (MW)	Scrubber Δ 2nd Stage ($in.H_2O$)	Flue Gas Flow* (ACFM)	L/G	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	2nd Stage Liquid Flow (gpm)
1400	146	6.2	159,700	31.9	6.0	1150	205	82.2	5100
1415	-	6.4	159,700	31.9	6.9	1140	200	82.5	5100
1430	-	6.4	159,700	31.9	6.9	1140	200	82.5	5100
1500	-	6.0	159,700	36.9	7.0	1190	195	83.6	5900

* At the inlet to the first scrubber stage.

TABLE 6-8. BOILER/SCRUBBER DATA

Date: 17 December 74 Time Span: 0900-1400 Test Condition: Experiments changing the liquid flow rate in the scrubber 2nd stage.

Time	Boiler Load (MW)	Scrubber Δ 2nd Stage (in. H_2O)	Flue Gas Flow (ACFM)*	L/G	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Liquid Flow Rate (gpm)
0900	151	3.7	130,600	42.0	7.2	790	165	79.1	5500
0950		8.2	159,700	36.9	7.1	1050	170	83.8	5900
1000	162	8.2	159,700	36.3	7.1	1050	170	83.8	5800
1035		8.0	140,800	52.5	7.0	1020	135	86.8	7400
1100	174	8.7	159,700	42.6	7.0	950	135	85.8	6800
1130		7.4	165,900	31.3	7.0	900	170	81.1	5200
1150		6.2	165,900	24.1	7.0	850	195	77.1	4000
1200	182	6.0	180,200	22.8	7.1	960	180	81.3	4100
1225		6.6	180,200	27.7	7.2	880	180	79.5	5000
1245		8.3	197,600	25.3	7.3	810	120	85.2	5000
1300	182	8.5	196,600	25.3	7.1	810	135	83.3	5000
1320		9.5	173,100	33.5	-	805	110	86.3	5800
1400	182	9.7	180,200	32.2	7.2	790	110	86.1	5800

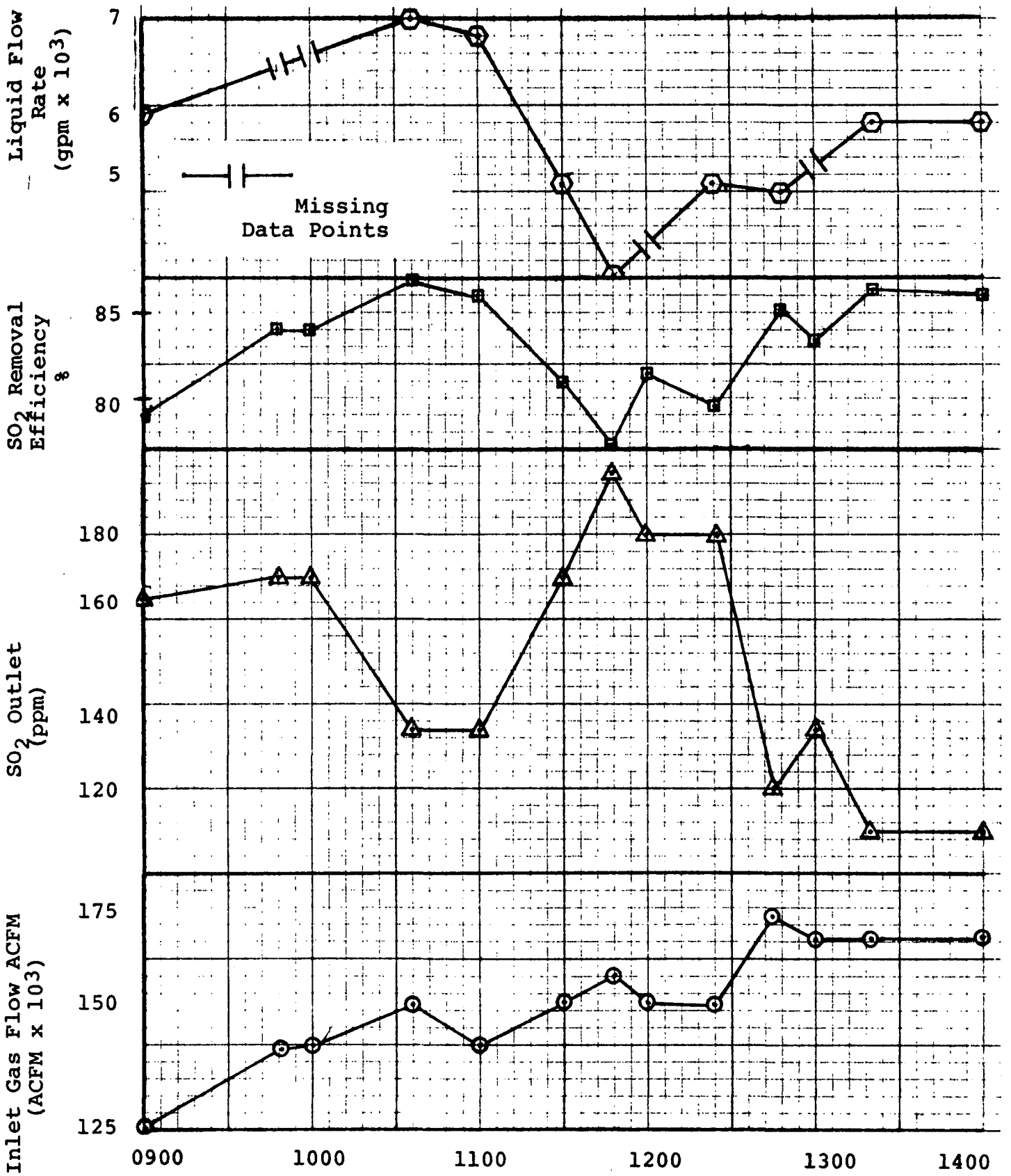
* At the inlet to the first scrubber stage.

The experiment conducted on December 14 was run under normal scrubber operating conditions. As can be noted in Table 6-7, a liquid to gas ratio (L/G) of 31.9 was maintained until the last point where it increased to 36.9. The Chemico scrubber design specified an L/G ratio in units of gallons/(1000 ft^3) at 117^oF as 20 for the first stage and 40 for the second. It is apparent that the second stage venturi was operated below the design specifications during this experiment. However, as the L/G ratio approached 40, an increase in the scrubber efficiency was observed.

In order to further evaluate the effect of the L/G ratio and determine optimum value, further studies were conducted on December 17, 1974. The difficulty in interpreting these results lies in the fact that the Δp across the scrubber second stage was not generally held constant.

In order to better depict the flows and efficiencies of the 17th, Figure 6-2 is presented. Figure 6-2 shows how the SO_2 removal efficiencies followed the re-circulating flow variations produced during the experiment. As the liquid flow rate increased so did the SO_2 removal efficiency

By isolating the four readings in Table 6-7 from 1035 to 1150 the interaction of re-circulating flow and SO_2 removal efficiency at constant pH can be studied. As is shown during this period in Table 6-9, the pH of the absorber remained constant at 7.0. The re-circulation rate, however, was steadily decreased from the 7000 gpm level at 1035 to the 4000 gpm mark at 1150, the result was a drop in efficiency of almost 10 percent. The second Δp also dropped reflecting the fall in the re-circulaion rate.



LIQUID FLOW RATE VARIATIONS
12/17/74

FIGURE 6-2

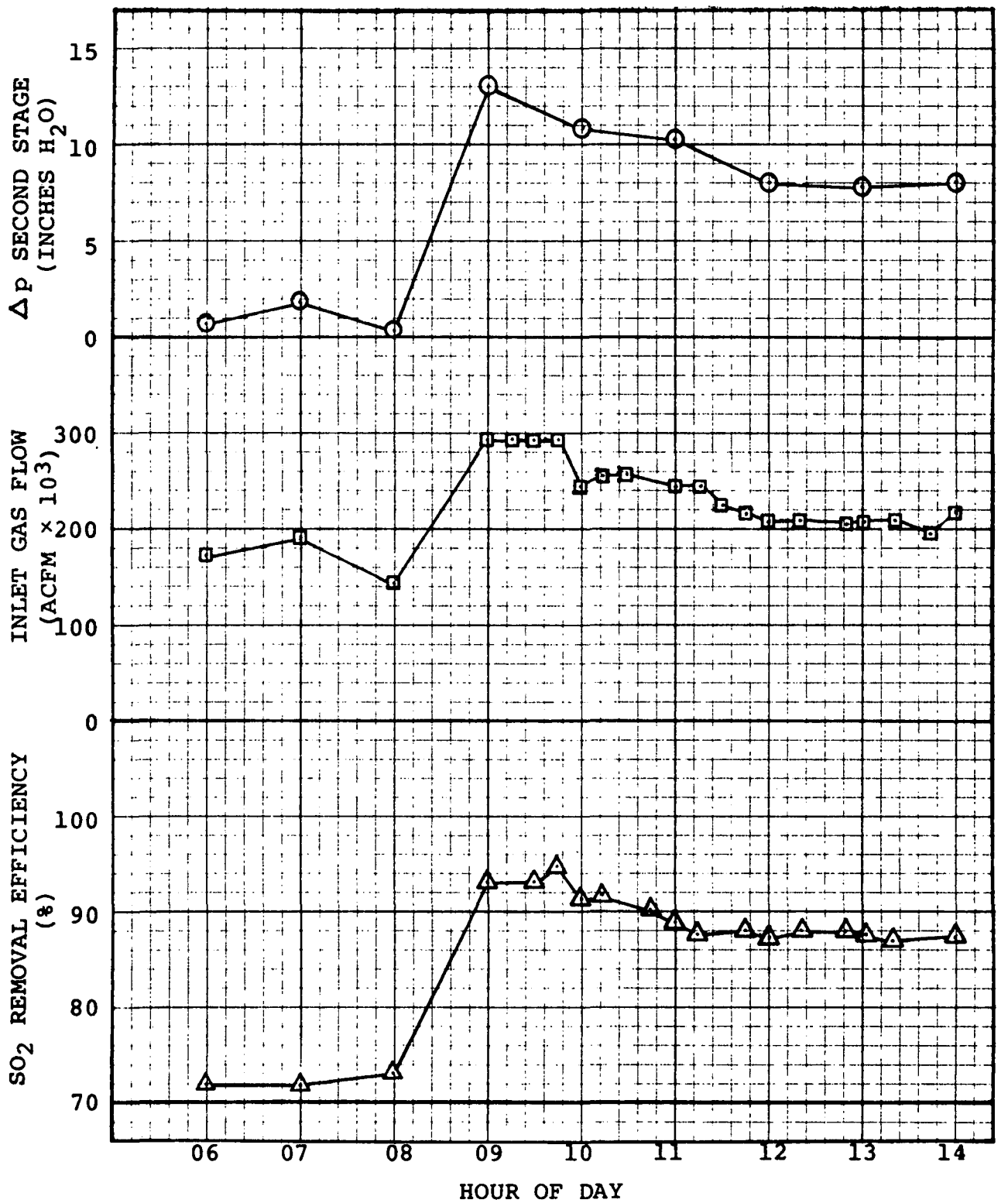
TABLE 6-9. LIQUID FLOW RATE CHANGES
December 17, 1974

Time	pH	Gas Flow (ACFM)	Second Stage Δp	Liquid Flow Rate (gpm)	L/G	SO_2 Removal Efficiency %
1035	7.0	140,800	8.0	7400	52.5	86.8
1100	7.0	159,700	8.7	6800	42.6	85.8
1130	7.0	165,900	7.4	5200	31.3	81.1
1150	7.0	165,900	6.2	4000	24.1	77.1

The second operating parameter to be changed on the second stage was the pressure drop across the throat of the venturi scrubber. Since the throat of the scrubber is of a fixed size and the liquid flow rate is normally at a constant volume, the only other parameter which affects the pressure drop across the throat is the volume of gas flowing through the venturi. With this in mind, tests were conducted on January 27, 1975 to assess the affects of varying gas flows at a constant re-circulating rate of 5000 gpm.

Gas flow rates approximately equal to the design specifications were run through the scrubber for approximately one hour, and were then maintained at lower levels for five additional hours. Higher SO_2 removal efficiencies were obtained during the operation at high flows. Data shown on Table 6-10 indicate that with lower gas flows in the 100,000 ACFM range, the SO_2 removal efficiencies were approximately 80 percent. When the gas flow increased to 290,000 ACFM the efficiency rose to over 90 percent.

The close correlation that exists between flue gas flow rate, second stage Δp, and the unit's efficiency throughout this period of high gas flows is illustrated very well in Figure 6-3. At 0900, when the flue gas flow rate was above 290,000 ACFM, second stage Δp was 13.0 inches H_2O



HIGH GAS FLOW
1/27/75

FIGURE 6-3

TABLE 6-10. BOILER/SCRUBBER DATA (1/27/75)

Time	Boiler Load (MW)	Scrubber Δp (2nd Stage)	Flue Gas Flow (ACFM)	Slurry pH	SO_2 (ppm) inlet/outlet	SO_2 Removal Efficiency (%)
0600	116	0.7	169,400	7.4	1000/280	72.0
0700	163	1.8	188,300	7.4	1000/280	72.0
0800	176	0.2	141,200	7.5	900/240	73.3
0900	162	13.0	291,800	7.5	900/63	93.0
0915			291,800		-	-
0930			291,800		900/63	93.0
0945			291,800		900/50	94.4
1000	116	10.8	242,200	7.4	910/80	91.2
1015			255,000		900/75	91.7
1030			255,000		-	-
1045			255,000		900/90	90.0
1100	138	10.2	242,200		940/105	88.8
1115			242,200		900/110	87.8
1130			222,400		-	-

TABLE 6-10. BOILER/SCRUBBER DATA (1/27/75) (Continued)

Time	Boiler Load (MW)	Scrubber Δp (2nd Stage)	Flue Gas Flow (ACFM)	Slurry pH	SO_2 (ppm) inlet/outlet	SO_2 Removal Efficiency (%)
1145			218,100		1000/120	88.0
1200	174	8.0	207,400	7.2	1020/130	87.3
1220			207,400		1000/120	88.0
1235			207,400		-	-
1250			200,400		1000/120	88.0
1305	175	7.8	207,400	7.3	1020/125	87.7
1320			207,400		1000/130	87.0
1345			197,600		-	-
1400	174	8.0	218,100	7.1	1020/125	87.7

and the unit efficiency was a very high 93 percent. However, once the gas flow was decreased to 242,200 ACFM at 1100, second stage Δp fell to 10.2 inches H_2O and the efficiency dropped to 88 percent.

It would have been valuable if the rapidity of solids build-up in the absorber could have been monitored when the gas flow was high. It would have provided some measure of the requirements to be placed on the centrifuge, and possibly delineated a constraining factor on continued high gas flow operation. From the data available it is known that the solids in the second stage bleed were 1.39 percent. Solids levels rose to 7.51 percent at 1200, when the efficiency was 88 percent. Greater solids formation at higher efficiencies was observed. It can only be speculated as to what the solids build-up amounted to at 0930 when efficiency was 93 percent, but if above 10 percent, it probably placed undue strain on the pumps and pipes. This possibility would have to be investigated fully in conjunction with the ability of the centrifuge to work down the solids before making a final assessment on the benefit of a high gas flow for this demonstration plant.

The data from the December 17th tests (Table 6-8) also demonstrated that efficiency rises by increasing gas flow and maintaining the liquid flow rate constant. The readings for 1225 and 1245, reproduced below, show the same liquid flow rates of 5000 gpm, but differing gas flows. Since the gas flow at 1245 was higher than at 1225, second stage Δp increased, and SO_2 removal efficiencies rose by almost 6 percent in 20 minutes.

TABLE 6-11. TEST RESULTS - DEC. 17, 1974

Time	Flue Gas Flow (ACFM)	Second Stage Δp	Liquid Flow Rate (gpm)	SO_2 Removal Efficiency (%)
1225	180,200	6.6	5000	79.5
1245	197,600	8.3	5000	85.2

In concluding the experiment on liquid flow rate changes (Table 6-8), high gas flows were combined with high liquid flow rates, and higher efficiencies were the result. At 0950, a 5900 gpm liquid flow rate and an 8.2 inch H_2O Δp produced an 83.8 efficiency, whereas at 1320 a 5800 gpm liquid flow rate and a 9.5 inch H_2O Δp produced an 86.3 percent efficiency. It was the higher gas flow rate at 1320 that increased the second stage Δp and produced the greater efficiency.

The third parameter that was changed on the absorber was the restrictor in the throat of the second stage venturi. During the boiler shutdown between February and August 1975, several modifications were made to the system, one of which was the removal of the restrictor in the second stage venturi throat. This change was made by Chemico in order to provide data on operation at a reduced pressure drop while maintaining a design gas flow rate.

In order to demonstrate the effect of removing the throat restriction, Table 6-12 provides data from a test run on August 26, 1975. It is seen that there is a dramatic decrease in the Δp for a given flow rate with a correspondind decrease in SO_2 removal efficiency. The data in Table 6-13 are extracted from Tables 6-8 and 6-12 to demonstrate this point.

TABLE 6-12. BOILER/SCRUBBER DATA

Date: 26 August 75 Time Span: 0400-1400 Test Condition: Rapid Velocity Change

Time	Boiler Load (MW)	Scrubber Δp Second Stage (in.H_2O)	Flue Gas Flow (ACFM)*	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0400	176	3.2	188,400	6.9	1300	390	70.0
0415			120,300		1200	400	66.7
0500	183		130,600		1200	420	65.0
0515			160,000		1380	470	65.9
0600	180	3.4	198,700	6.9	1320	400	69.7
0700	176		125,400		1350	470	65.2
0710			130,600			470	65.2
0715			120,300		1300		
0716			130,600		1200		
0717			130,600		1150		
0718			130,600		1370		
0719			125,400		1350		
0720			130,600		1300		
0730			125,400			470	63.9
0800	177	0.9	125,400	7.2	1340	540	59.7
0815			125,600		1340	540	59.7
0900	176		120,300		1350	490	63.7
1000	178	0.8	120,300	7.1	1340	450	66.4
1030			120,300		1290	420	67.4
1045			146,400		1290	420	67.4
1100	180		140,800		1250	410	67.2
1200	184	1.6	146,400	7.1	1250	420	66.4
1230			146,400		1250	420	66.4

* At the inlet to the first scrubber stage.

TABLE 6-12. BOILER/SCRUBBER DATA (CONT.)

Date: 26 August 75 Time Span: 0400-1400 Test Condition: Rapid Velocity Change

Time	Boiler Load (MW)	Scrubber Δp Second Stage (in.H_2O)	Flue Gas Flow (ACFM)*	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1245			173,000	7.1	1200	370	69.2
1300	185		173,000		1200	350	70.8
1330			198,700		1120	320	71.4
1345			198,700		1100	300	72.7
1400	185	3.6	198,700	6.8	1100	300	72.7

* At the inlet to the first scrubber stage.

TABLE 6-13. ALTERATION OF Δp

Date	Time	Δp	Gas(ACFM)	SO_2 Removal Eff.
12/17/75	1035	8.0	140,800	86.8
8/26/75	1100	1.6	140,800	67.2

Without additional details to describe the design of the venturi, further extrapolations as to the energy required in the form of a pressure drop across the venturi to predict SO_2 removal efficiency cannot be made.

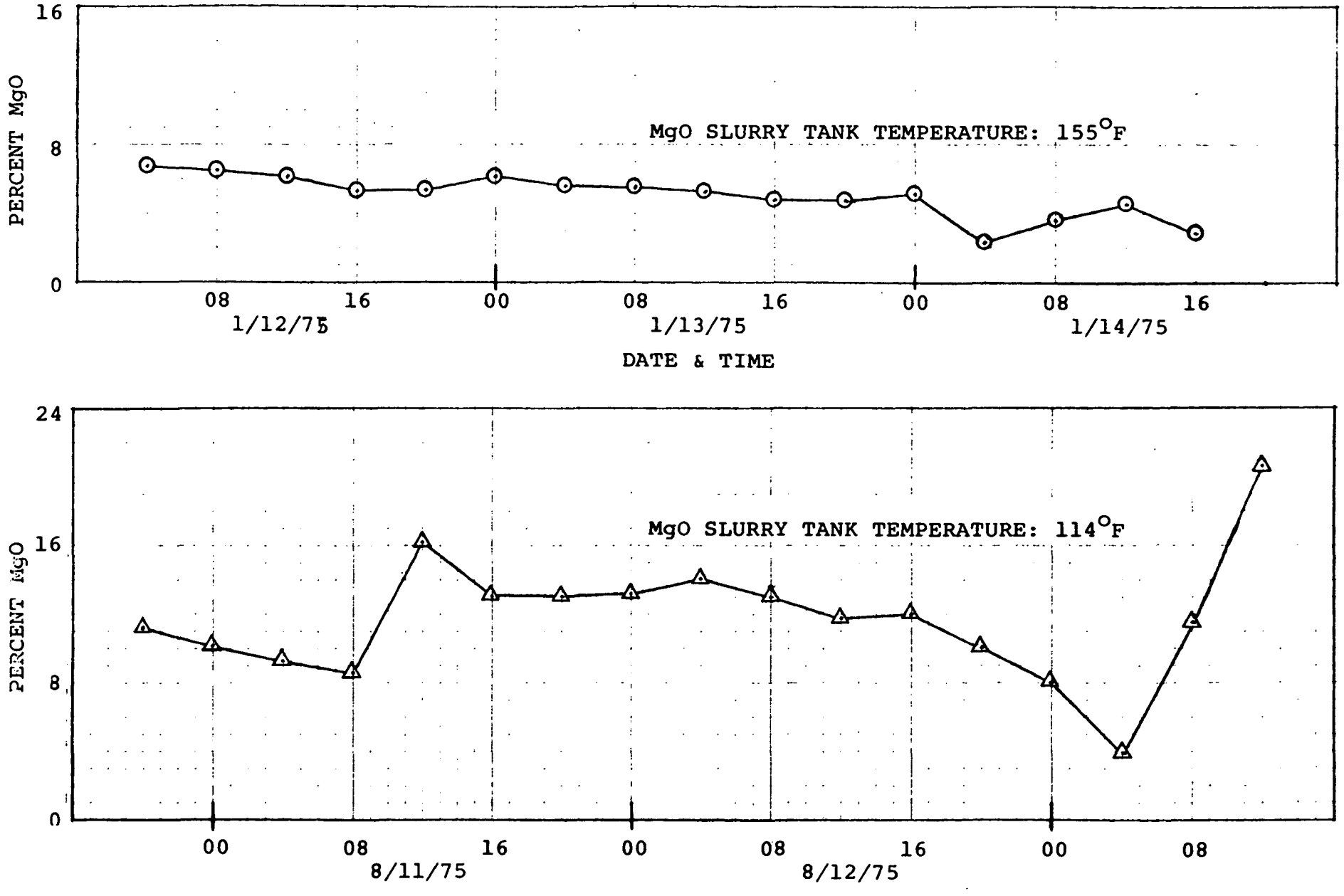
6.2.2 MgO Slaking

No deliberate attempts were made to change any of the parameters in the MgO slaking operation. The control system was set up so that the pH of the second stage recycle line was maintained at approximately 7 throughout the test program.

On August 11, 1975 the malfunction of the steam control valve on the MgO slurry tank provided the opportunity to observe the effect of reducing the amount of steam to the slaking process. A result of this heat reduction was a decrease of the efficient usage of MgO. This is clearly illustrated in Figure 6-4 which shows the percent of unreacted MgO appearing in the centrifuge cake during a period of normal heating, and during a period when the heating system was inoperable.

The large amount of MgO in the centrifuge cake eventually created a major problem in the dryer. On August 15, 1975, the dryer was plugged with a rock-hard material.

Subsequent analysis of this material indicated the existence of a large concentration of inerts, which were hypothesized to be oxysulfate. An oxysulfate cement is formed by the reaction of magnesium oxide which has been produced by the calcination of a magnesium compound, with a solution of magnesium sulfate of suitable concentration . Since



UNREACTED MgO IN CENTRIFUGE CAKE AS A FUNCTION OF TEMPERATURE

FIGURE 6-4

a large amount of free water was present during this run and available MgO was present, the 10-20% concentration of $MgSO_4 \cdot 7H_2O$ in the free water reacted with the available MgO to form the oxysulfate cement.

As a result of the problems incurred with the breakdown of the steam control valve and the evaluation of the resultant data collected, it becomes evident that the MgO slurry tank must be operated at some optimum temperature from an economical and operational standpoint. The object in maintaining this temperature is to arrive at an optimum amount of MgO of sufficient activity in the re-circulation lines and especially in the centrifuge cake. Since these observations were made at the end of the testing program, insufficient time was available to study this problem further.

6.2.3 Solids Removal System

Throughout the operating period of the scrubber system, there was no control system to regulate the solids concentration in the second stage absorber. Samples were collected, however, at 4-hour intervals to monitor the percent solids for purposes of analyzing the performance of the system.

Upon reviewing the data collected prior to the completion of the scrubber testing in January, 1975, Chemico stated that they wished to operate the centrifuge at a different rotational speed to determine removal efficiency at a second separational force. Table 6-14 shows the data collected on December 6-8, 1974 from operations at a higher torque, and from August 12-14, 1975 from operations at lower torque. No definite statements can be made concerning the solids removal efficiency at rates greater than 24 g's; however, as the separation force decreases from this point, the efficiency also definitely decreases.

TABLE 6-14. SOLIDS REMOVAL EFFICIENCY DATA
Data for Dec. 6-8,'74 and Aug. 12-14,'75

	Higher Torque Operation					Lower Torque Operation			
	2nd Bleed % Solids	Torque	Mother Liquor % Solids	% E		2nd Bleed % Solids	Torque	Mother Liquor % Solids	% E
12/6	9.07	58	8.91	1.7	8/12	3.5	22	2.92	16.6
MidN.	7.62	40	2.72	64.3	MidN.	4.0	26	0.39	90.3
	7.04	40	3.79	46.2		3.14	24	0.39	87.6
	8.32	50	3.14	62.2		4.20	28	NA	--
	11.92	52	2.75	76.9		3.01	32	0.67	77.7
	13.29	46	3.20	75.9		6.81	45	0.88	87.1
12/7	10.36	46	5.24	49.4	8/13	7.19	52	2.87	60.1
	10.06	50	3.92	61.0		7.76	43	1.91	75.4
	11.18	50	4.08	63.5		8.25	42	2.23	73.0
	9.34	40	3.08	67.0		7.23	32	2.51	65.3
	10.90	40	3.70	66.1		7.97	36	2.82	64.6
	14.57	45	4.01	72.4		9.28	32	3.35	63.9
12/8	10.89	44	5.36	50.8	8/14	8.83	8	7.03	20.4
	11.98	44	5.49	54.2		19.79	OFF	3.45	82.6
	11.17	40	4.18	62.6		2.56	3	2.29	10.5
	11.88	44	4.22	64.5		2.61	1	2.59	0.8
	12.08	24	NA	--		3.07	2	3.32	--
	11.95	27	3.68	69.2		4.77	14	4.39	8.0
Average	10.76	43	4.20			6.33	26	2.59	

A second parameter that is of importance in the operation of the centrifuge is the amount of magnesium sulfite that is in the hexa-hydrate form as opposed to the trihydrate form. The hexa-hydrate form has a large crystalline structure which allows the centrifuge and dryer to operate more efficiently. Experimental studies were conducted by YRC to determine the percent combined H_2O in the centrifuge cake that was of the hexa-hydrate as opposed to the tri-hydrate form of magnesium sulfite. The test results indicate that at least 80% of the product in the centrifuge cake was of the form $MgSO_3 \cdot 6H_2O$.

Observations that were made on a similar magnesium oxide scrubber at Boston Edison's Mystic Station indicated that the tri-hydrate form of magnesium sulfite was the predominant form of the product. To further investigate this reaction, the U.S. EPA commissioned Radian Corporation to study the kinetics and equilibrium of the hydrate formations. The report on this study will soon be published.

6.3 Performance

The Dickerson MgO system was capable of removing 90% of the sulfur dioxide produced when burning coal containing 2% sulfur.

6.3.1 SO2 Removal Efficiency

From the beginning of full scale testing on October 15, 1974 to the completion of testing on January 27, 1975 the scrubber system was normally able to attain efficiencies of between 78-83%. Maximum efficiencies of 96-97% were obtained at high flue gas flow rates on short duration runs of several hours, but difficulties in running the MgO feed system and solids separation system for the second stage at high flow rates necessitated that the system generally be run at 75% of the designed flue gas flow rate.

During the down period of January 27, 1975 to August 11, 1975, the restrictor plate in the venturi throat was removed to observe the performance at a lower Δp. From August 11, 1975 to September 27, 1975, an average efficiency of between 70-75% was attained. No attempts were made to run the system at high gas flow rates due to the problems with the feed system and the solids separation system for the second stage.

The parameter that affected the SO_2 removal efficiency the most was determined to be the pressure drop across the venturi throat. This parameter is a measure of energy usage required to make the system work. In order to reach efficiencies greater than 90%, a pressure drop of at least 11 inches of H_2O was required. This value was achieved with close to design gas flow rates flowing through the venturi at an approximate L/G of 20. A second parameter that was studied was the liquid to gas ratio. It was found that doubling the volume of recirculating slurry at a pH of 7.0 increased the SO_2 removal efficiency by only 10 percent at lower gas flow rates; however, an increase of 10 to 20% in the SO_2 removal was incurred by increasing the pressure drop across the venturi throat with higher gas flow rates.

6.3.2 Particle Removal Efficiency

The provision to by-pass the ESP and send flue gas with a heavy concentration of particles to the scrubber worked very well in demonstrating the ability of the FGD system to attain a high particle removal efficiency in excess of 99%. One concern that is coupled with this high removal efficiency is the possible build-up of inert flyash in the second stage solids. Since the FGD system was not operated enough to attain a high recycle rate of MgO, no data were recorded that indicated that there was a flyash build-up problem. As with all power plant scrubber

particle removal systems, the problem of the ultimate disposal of the flyash slurry from the first stage must be given careful consideration due to its low pH and high chloride concentration.

6.3.3 Duration of Scrubber Performance

Throughout the full scale testing program time period of October 18, 1974 to January 27, 1975 and August 11, 1975 to September 27, 1975, the scrubber was operating approximately 53% of the time. Many of the scrubber outages were the result of leaks which developed in the first and second stage recycle systems, and also due to the lack of MgO raw material make-up. In order for a system of this size to operate without interruption, at least twice as much material storage must be available to counteract the shipment problems which occurred throughout the project. On-site storage was only 100 tons which at design conditions was about a month's supply. A second storage problem arose with the disposal of the magnesium sulfite product. A 200 ton storage silo was employed at the Dickerson site which proved to be inadequate due to the erratic operation of the MgO regeneration station in Rumford, Rhode Island, which would certainly not be representative of a commercial unit. As a result of experiencing these storage problems, it is apparent that a reliable regeneration facility is necessary to make the MgO FGD process a viable system.

7.0 CONCLUSIONS

The test program has shown that the SO_2 removal efficiency of the MgO venturi scrubber is principally dependent upon both the pressure drop, and the liquid to gas ratio of the second stage venturi absorber. Removal efficiencies of over 90 percent were attained with an 11 inch (H_2O) pressure drop.

The particle removal efficiency of the first stage was greater than 99 percent when the flue gas was taken directly to the scrubber from the boiler, and not pre-conditioned by the ESP.

The overall performance of the scrubbing system was satisfactory, aside from difficulties experienced with materials and equipment (which have been documented herein). During transient operation, operational problems and high emission levels were generally normalized soon after the upset occurred. Sustained operation was never experienced, and as a result data obtained are only representative of those short periods studied.

Availability percentages were rather low but this was only partially due to the basic scrubber design. The distance and nature of the MgO recovery operation often caused scrubber shut-downs due to lack of raw materials. Low availability was also due to:

- Lack of proper recirculation systems.
- Lack of pipe linings.
- Auxiliary equipment problems.
- Lack of sufficient number of operators.
- Boiler shut-downs.

If these deficiencies were corrected, efficiency and availability would have been significantly improved.

The aforementioned problems also reduced the time and effort that should have been spent on experimentation and optimization of the process. For the most part, work done to test the operation proved successful. An example of this would be the study of liquid to gas ratios, and high gas flows. Unfortunately, there were not enough such investigations to fully characterize and optimize the process.

It is recommended that consideration be given to further testing of the MgO process in order to better characterize the system under longer term operation and to demonstrate commercial availability.

REFERENCES

1. YRC Report 4-8864: Preliminary Report for the Evaluation of Particulate Emission Control at PEPCO's Dickerson Station. PEPCO Report dated 10/31/75.

2. Federal Register, Vol. 37, No. 247, Dec. 23, 1971.

Conversion Factors: British to SI Units

To Convert From	To	
Length		
inch (in.)	meter (m)	multiply by 0.0254
foot (ft.)	meter (m)	multiply by 0.3048
Mass		
pound (lb.)	kilogram (kg)	multiply by 0.4535924
ton	kilogram (kg)	multiply by 907.1847
grain	kilogram (kg)	mulitply by 0.0000648
Volume		
cubic foot (CF, ft^3)	cubic meter(m^3)	multiply by 0.02832
gallon (gal)	cubic meter(m^3)	multiply by 0.003785
Energy		
British thermal unit (Btu)	calorie (cal)	multiply by 251.9958
Temperature		
Fahrenheit(^oF)	Celsius (^oC)	$^oC = 5/9\ (^oF - 32)$
Celsius (^oC)	Kelvin (K)	$K = {}^oC + 273.16$

APPENDIX A

SCRUBBER EQUIPMENT LIST
AND
EQUIPMENT SPECIFICATIONS

Scrubber Equipment List

Item Description	Code No.	Quantity	Motor Horse-power (HP)
MgO Make-Up Tank	G-101	1	
Dust Collector-MgO Silo	G-102	1	
Thickener	G-201 A,B	2	
Transfer Tank	G-202	1	
Distribution Box	G-203	1	
Sump Tank	G-204	1	
Mother Liquor Tank	G-301	1	
Dust Collector-Dryer	G-401	1	
MgO Storage Silo	I-101	1	
$MgSO_3$ Silo	I-401	1	
MgO Feed Pump	J-101 A,B	2	10
First Stage Recycle Pump	J-201 A,B	2	350
Second Stage Recycle Pump	J-202 A,B,C	3	250
Underflow Pump	J-203 A,B,C,D	4	
Transfer Pump	J-204 A,B	2	125
Sump Pump	J-205	1	30
Mother Liquor Pump	J-301 A,B	2	20
Induced Draft Fan	K-201	1	3500
MgO Agitator	M-101	1	5
Mother Liquor Agitator	M-301	1	3
MgO Weigh Feeder	0-101	1	
Dryer Feed Conveyor	0-401	1	1
Dryer Discharge Conveyor	0-402	1	2
Dryer Discharge Elevator	0-403	1	2
$MgSO_3$ Weigh Feeder	0-405	1	
Two-Stage Venturi Scrubber	R-201	1	
Mist Eliminator	R-202	1	
Variable Speed Coupling	R-203	1	
Centrifuge	R-301	1	200
Rotary Dryer	R-401	1	40
Dryer I.D. Fan	K-402	1	100
Instrument Air Dryer	V-101	1	

GENERAL SPECIFICATIONS - SO_2 REMOVAL SYSTEM

EQUIPMENT

1. MgO System

MgO Make-Up Tank (G-101)
MgO Storage Silo (I-101)
MgO Feed Pumps and Motors (J-101 A & B)

Agitator (M-101)

One paddle type agitator (Denver, or equal), including enclosed reducer with coupling, shaft, three 8" deep horizontal paddle arms 7' diameter and 45 degree angular paddle in tank conical section, beam type superstructure V-belt drive, drive guard 5 HP, 900 rpm-TEFC motor and motor base. Includes seal and seal plate to mount on tank cover around the shaft. Paddle speed 8 rpm, reducer ratio 48 to 1; wetted parts mild steel construction.

MgO Weighing System (0-101)

One gravimetric feeder which provides a continuous measurement of weight through a scale; compares the measurement signal with the set point through suitable control instrumentation, and actuates a hopper gate to provide a constant feed of material. A section of the constant speed weight belt is weighed by means of mechanical levers and a scale beam. Beam deflection is transmitted mechanically via a link connection to a regulator that adjusts the feed gate. Unit includes self contained belt feeder mechanical weight control loop, totalizer, totally enclosed pulley transmissions, and static test weights, capacity 0.5 to 1.5 Standard Tons Per Hour (STPH).

MgO Supply Conveyor (0-102)

One conveyor handling 25 STPH of magnesium oxide with bulk density of 25 lbs/cu.ft. from the truck unloading hopper to the silo feed elevator.

2. Absorption System

1st Stage Recycle Pumps and Motors (J-201 A,B)
2nd Stage Recycle Pumps and Motors (J-202 A,B,C)
I.D. Fan and Motor (K-201)
Scrubber (R-201)

3. Centrifuge System

Mother Liquor Tank (G-301)
Mother Liquor Pumps and Motors (J-301 A,B)

Centrifuge (R-301)

One 36" x 72" carbon steel solid bowl continuous centrifuge, (Bird or equal), including 200 HP, 460 volt, 3 phase, 60 cycle

TEFC motor with high thermal capacity. A main bearing forced oil circulating system is provided with pump, drive motor, oil filter, heat exchanger, pressure switch and gauge, and oil reservoir. An outlet chute is included.

4. Dryer System	Description
$MgSO_3$ Silo (I-401)	
Rotary Dryer (R-401)	One rotary dryer, to produce the anhydrous products $MgSO_3$, $MgSO_4$ and MgO as follows:
Size of dryer	8'0" diameter x 50'0" long
Shell plate	½"
Feed end head	5' - 0" diameter x ½" plate
Number of riding rings	2
Riding rings	8'10" diameter x 7" face
Support rollers	20" diameter x 9" face
Thrust roller	16" diameter x 2½" face
Hammers	2 sets of 8
Feed end chamber	Breaching where the feed conveyor enters the dryer

Dryer Dust Collector (G-401)

One cyclone with scroll outlet for 97% removal, plus rotary discharge valves. The fines collected by the collector will return directly to the dryer product conveyor.

Dryer I.D. Fan (K-401)

One induced draft fan, with inlet and outlet flanges, inspection door, drain, dampler, V-belt drive, drive guard, and 100 HP, 3 phase, 60 cycle, 230/460 volt, 1,800 rpm, TEFC, motor.

Fan Performance Data

Volume	26,500 CFM @ $400^{o}F$
Static Pressure	8" S.P.
Speed	1,800 rpm

Dryer Combustion Chamber

One direct fired air heater approximately 6' - 0" O.D. x 18'-0" long, and designed to operate with the following:

Maximum Heat Release	$26.3\ 10^{6}$ Btu/hr
Inlet Temperature	$70^{o}F$
Combustion Chamber Temp.	$1,600^{o}F$
Site Elevation	Sea Level
Operating Furnace Pressure	Balanced
Fuel	No. 2 fuel oil
Maximum Oil Viscosity	40 SSU, constant
Type Fuel Oil Atomization	Air
Burner Turndown	5:1
Insurance Requirements	F.I.A.

Fuel Oil Supply for Combustion Equipment (R-401)

A duplex fuel oil pumping and straining set, designed to meet the following conditions will be provided to supply fuel oil to the air heater burner:

Fuel Oil	No. 2
Design Capacity	3 gpm
Pump Discharge Pressure	125 psig
Maximum Suction	Plus 30 psig Minus 13" Hg
Electric Service	440 volt, 3 phase, 60 cycle

Dryer Feed Conveyor (0-401)

One 12" diameter x 5'0" long heavy duty ribbon feeder conveyor, complete with 3 HP drive.

Dryer Discharge Elevator (0-403)

One elevator which elevates 5 STPH of dried magnesium sulfite with a density of 50 lbs/cu.ft. discharging from the dryer to the magnesium sulfite bin.

SCRUBBER INSTRUMENTATION AND CONTROLS

The system has two separate control panels as follows:

1. The scrubber/absorber control panel (SCP) located in the prefab building south of the mist eliminator vessel.

2. Main control panels (VB and BB) located in the main control room of the existing powerhouse building.

Scrubber/Absorber System Control Panel

The following controls are located on the control panels located in the prefab building and their names and functions are described.

PDR-1	pressure drop recorder for first stage of scrubber absorber
FRI, 1,2	first stage recycle liquor flow rate indicator
LIC 1	level indicator - controller for first stage scrubber
LIC 11	level indicator - controller for transfer tank
HIC 10	manual loader for bleed from first stage to distribution box
WI 28,29	torque indicators on thickener rakes A and B
PDR 3	pressure drop recorder for second stage of scrubber/absorber vessel
FIC 5	flow indicator - controller, MgO slurry to scrubber
HIC 4	manual loader for bleed from second stage to centrifuge
LIC 2	level indicator - controller scrubber 2nd stage
WR 11	torque recorder, centrifuge
LIC 7	level indicator - controller,MgO make up tank
LIC 8	level indicator - controller, mother liquor tank
FR 20	flow recorder, mother liquor to MgO tank

TR 8	temperature recorder, dryer outlet gas
TIC 8	temperature indicator - controller, dryer outlet gas
PIC 12	pressure indicator - controller, dryer outlet gas
FR 23	flow recorder, fuel oil flow to dryer
TJR 4	six point temperature recorder:

1. flue gas, dryer exit
2. product discharge, dryer
3. cyclone inlet, dryer
4. spare
5. spare
6. spare

WCIQ 18	controller, totalizer $MgSO_3$ feeder
TISH 1A,1B	temperature indicating switches, 2nd stage scrubber inlet
FI 7	flow indicator, make up liquid to 1st stage from transfer pumps
PDI 2	mist eliminator pressure drop, 1st stage
PDI 4	mist eliminator pressure drop, 2nd stage
FI 6	flow indicator, centrifuge feed
FI 4	flow indicator 2nd stage scrubber, upper cone, recycle loop
FI 3	flow indicator 2nd stage scrubber, lower cone, recycle loop
AIC 1	SO_2 inlet/outlet concentration indicator
AR 2	pH recorder, bleed to centrifuge
AI 2	pH indicator, bleed to centrifuge
WCIQ 17	controller totalizer, MgO weigh feeder
TISH 9	temperature indicating switch, dryer combustion chamber outlet
II 9A,B	ammeters, 1st stage scrubber recycle pumps
ZI - 1A	scrubber cone position indicator
HS 9	transfer pump selector switch
II 10A,B,C	ammeters, 2nd stage scrubber recycle pumps
HS 14	mother liquor pumps, selector switch
HS 15	MgO makeup pumps, selector switch
HS 5	hand selector switch, recycle pumps, 1st stage

Main Control Panel

The following controls are located in the control room in the main building. Their names and functions are given below:

PDA 1	plumb bob position and pressure differential, 1st stage
PAL 20	low pressure alarm ID fan fluid drive
TAH 5	high temperature alarm ID fan drive bearings
TAH 10	high temperature alarm ID fan fluid drive accessories
XAH 7	alarm, ID fan vibration
IA 8	ID fan motor trip
FALL 2B	low low flow, scrubber recycle, first stage
FALL 7B	low low flow scrubber makeup, first stage
TAHH 2B	high high temperature, gas inlet 2nd stage
ZI 1B	position indicator, plumb bob

HS 12	auto manual station, plumb bob
HS 4	precipitator mode selector switch
HS 17	raise lower switch, plumb bob
TISH 5	alarm annunciator motor, fan and fluid drive bearings
II 7	ammeter, ID fan motor
HS 22	start, stop switch ID fan
PDIC 1	pressure indicator controller, plumb bob, lst stage
HS 6	hand selector switch, recycle pumps, 2nd stage
HS 16	selector switch, pond water return pump

APPENDIX B

DATA TABULATION

DATA TABULATION

These tables represent the hourly data obtained during the testing period. When data are missing, an (NF) or an asterisk (*) appears. An NF indicates that the instrument used to measure the parameter was not functioning. The asterisk indicates that the datum was not obtained, usually for a reason explained in the footnote, or otherwise unknown.

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	Scrubber 2nd Stage ΔP	Scrubber 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1974														
11-1	Scrubber	Down.												
11-2	Scrubber	Down												
11-3	Scrubber	Down												
11-4	Scrubber	Down												
11-5	Scrubber	Down												
11-6	Scrubber	Down												
11-7	Scrubber	Down												
11-8	Scrubber	Down												
11-9	Scrubber	Down												
11-10	0145	178	NF	4.0	NF[1]	NF	NF	NF	NF	NF	NF	NF	NF	-
	0220	178	NF	4.8	NF	NF	NF	NF	NF	150	360	12.2	8.5	-
	0300	158	NF	6.5	NF	NF	NF	NF	NF	125	350	13.0	8.7	-
	0345	148	NF	6.5	6.3	660	400	11.75	7.0	150	400	12.5	7.6	77.3
	0945	151	NF	5.5	6.4	680	400	13.5	6.8	160	400	13.5	6.8	76.5
	0545	151	NF	5.5	6.6	740	380	15.5	6.6	160	380	16.0	7.0	78.4
	0645	150	NF	4.9	7.3	700	390	15.0	7.6	150	400	15.0	7.6	78.6
	0745	151	NF	6.2	7.0	700	390	15.0	6.6	140	380	14.5	6.8	80.0
	0845	161	NF	6.0	7.0	1050	400	16.0	6.8	195	400	16.5	6.8	81.4
	0945	173	NF	6.2	6.5	NF[2]	NF	NF	NF	NF	NF	NF	NF	-
	1045	174	NF	1.0	6.8	900	NF	15.3	7.8	140	NF	10.5	>10.0	84.4
	1145	172	NF	1.0	6.8	920	NF	14.5	7.7	185	NF	11.6	>10.0	79.9
	1245	170	NF	3.5	7.1	970	NF	13.0	7.3	210	NF	11.5	9.5	78.4
	1345-1945	160	*	*	*	NF[3]	NF	NF	NF	NF	NF	NF	NF	-
	2045	173	NF	2.6	6.9	1050	390	14.5	9.5	220	330	13.0	>10.0	79.0
	2145	174	NF	4.2	7.0	1040	400	16.5	9.5	220	360	15.0	10.0	78.8
	2245	168	NF	4.2	6.8	1020	390	16.5	9.0	220	350	15.5	9.8	78.4
	2345	165	NF	5.0	7.0	1000	380	14.5	10.0	225	340	13.9	9.8	77.5
11-11	0045	147	NF	5.0	6.5	1000	380	15.0	9.6	220	340	14.0	9.8	78.0
	0145	147	NF	1.0	6.0	1000	370	14.0	9.2	220	NF	NF	NF	78.0
	0220	138	NF	0.0	5.6	1200	220	NF[4]	NF	1000	NF	NF	NF	-

[1] pH electrode broken; Start up
[2] Water in sample lines
[3] Water in analyzer lines
[4] Scrubber down 0220; Water leaks

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	Scrubber 2nd Stage ΔP	Scrubber 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-12	Scrubber Down - Start up at 2010													
11-13	2010	183	NF	6.0	NF[1]	NF	NF	NF	NF	NF	NF	NF	NF	-
	2030	182	NF	6.0	NF	550	460	13.0	7.6	180	440	12.0	7.8	67.3
	2130	183	NF	6.0	8.0	725	440	13.5	7.6	160	440	13.3	7.6	77.9
	2230	182	NF	6.0	*	1100	440	13.8	9.0	180	440	13.5	>10.0	83.6
	2330	184	NF	6.0	7.2	1200	440	14.0	9.0	280	400	13.5	8.6	76.7
11-14	0030	181	NF	0.8	*	1250	460	14.0	8.4	280	420	12.5	8.4	77.6
	0130	183	NF	1.8	6.7	1300	450	15.5	8.0	240	400	13.5	9.0	81.5
	0230	183	NF	3.0	*	1100	380	12.0	9.2	310	240	9.0	>10.0	71.8
	0330	183	NF	3.0	7.6	900	380	10.0	9.8	320	320	8.5	>10.0	64.4
	0430	182	NF	3.0	7.6	975	380	11.0	8.0	300	310	11.0	9.0	69.2
	0530	184	NF	*[2]	*	900	400	15.0	NF	350	360	13.5	NF	61.1
	0630	185	NF	3.0	7.6	900	420	14.0	NF	320	380	13.0	NF	64.4
	0730	177	NF	*	*	850	420	13.5	NF	280	390	13.0	NF	67.1
	0830	180	NF	3.0	7.5	650	420	14.5	NF	250	390	13.0	NF	61.5
	0930	180	NF	*	*	900	460	14.0	NF	125	420	13.5	NF	86.1
	1030	179	NF	6.5	7.0	925	460	16.0	NF	145	400	15.0	NF	84.3
	1130	136	NF	*	*	900	380	15.5	NF	150	340	15.0	NF	83.3
	1230	173	NF	5.0	7.1	925	420	15.0	NF	NF	NF	NF	NF	-
	1330	183	NF	*	*	650	400	NF	NF	115	390	NF	NF	82.3
	1430	180	NF	5.2	6.9	500	400	NF	NF	95	390	NF	NF	81.0
	1530	181	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1630	165	NF	3.0	6.9	1000	420	16.5	NF	180	360	11.5	NF	82.0
	1800	173	NF	7.0	7.0	1000	380	16.0	6.6	130	375	13.0	7.9	87.0
	1900	176	NF	*	*	900	400	15.5	6.5	150	360	15.0	7.4	83.3
	2000	172	NF	7.0	7.2	875	400	15.0	6.6	120	350	14.0	7.8	86.3
	2100	177	NF	*	*	925	400	14.0	9.0	130	370	12.0	9.0	85.9
	2200	176	NF	8.3	7.3	900	370	16.0	6.6	110	360	15.0	7.6	87.8
	2300	171	NF	*	*	900	400	15.0	6.6	140	360	14.5	7.8	84.4
	2400	173	NF	8.0	7.1	900	400	17.0	6.6	135	360	15.5	7.6	85.0

[1] Sample line leak
[2] Flow problems until 1800
CO_2 reading suspect until 1400, 11-15

HOURLY DATA

Date	Time	Inlet MW	Inlet ACFM x 1000	Scrubber 2nd Stage ΔP	Scrubber 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-15	0100	165	NF	*	6.5	900	410	16.0	6.6	160	370	15.0	7.4	82.2
	0200	165	NF	12.2	7.2	900	420	15.5	6.8	180	360	14.5	7.8	80.0
	0300	157	NF	*	7.5	800	400	16.0	6.4	160	390	15.0	8.0	80.0
	0400	167	NF	8.0	7.5	920	425	16.5	6.6	130	390	15.5	7.8	85.9
	0500	166	NF	*	7.5	1000	395	16.5	5.4	135	380	15.8	7.4	86.5
	0600	169	NF	8.0	7.5	910	420	17.0	6.2	128	390	16.0	7.8	85.9
	0700	171	NF	*	7.4	900	440	17.0	6.4	125	390	16.0	7.6	86.1
	0800	169	NF	8.0	7.4	900	420	15.8	6.6	125	400	15.4	7.5	86.1
	0900	175	NF	*[1]	7.4	700	420	15.9	6.4	120	400	15.5	7.6	82.9
	1000	180	NF	5.8	6.4	1150	440	15.5	6.5	250	400	14.3	8.0	78.3
	1100	182	NF	*	7.3	1300	440	15.8	6.8	340	360	13.4	9.5	73.8
	1200	178	NF	3.0	7.1	1100	438	15.3	6.9	265	360	13.2	8.8	75.8
	1300	178	NF	*	7.3	1050	420	16.5	6.7	240	360	14.5	8.8	77.1
	1400	178	NF	3.0	7.0	1050	460	11.0	6.8	270	290	10.0	8.5	74.3
	1500	182	NF	*	7.1	900	450	11.0	6.7	190	390	11.1	7.9	78.9
	1600	173	NF	5.2	7.1	900	420	11.0	7.6	190	400	10.5	8.0	78.9
	1700	176	NF	*	7.0	900	420	11.8	6.4	180	360	11.0	8.0	80.0
	1800	174	NF	5.2	7.0	900	400	11.3	6.2	170	350	11.0	8.4	81.1
	1900	168	NF	*	7.2	800	400	11.5	6.7	160	360	10.5	8.2	80.0
	2000	178	NF	7.0	6.9	800	420	10.5	6.8	160	380	9.8	8.0	80.0
	2100	179	NF	*	7.0	850	430	11.5	6.8	150	400	10.5	8.0	82.4
	2200	179	NF	7.0	7.1	800	430	13.0	6.8	130	400	12.5	7.8	83.8
	2300	179	NF	*	6.9	800	430	12.5	7.0	150	400	12.0	8.0	81.3
	2400	179	NF	7.0	7.0	850	420	12.5	6.8	170	390	12.0	7.8	80.0
11-16	0100	171	NF	*	7.1	800	430	13.5	6.8	140	420	12.5	7.8	82.5
	0200	174	NF	9.4	7.2	840	430	13.5	6.8	180	418	12.5	7.8	78.6
	0300	169	NF	*	7.3	800	420	13.5	6.8	120	400	12.0	7.6	85.0
	0400	174	NF	12.0	7.4	900	430	13.5	8.4	110	420	13.0	8.0	87.8
	0500	175	NF	*	7.4	850	430	14.0	6.4	90	420	14.0	7.0	89.4
	0600	177	NF	13.0	7.4	900	420	14.0	6.6	110	420	12.5	7.4	87.8
	0700	173	NF	*	7.4	900	430	12.5	7.0	100	410	12.5	7.2	88.9
	0800	175	NF	12.5	7.3	900	400	11.0	7.8	100	400	11.5	8.0	88.9

[1] Centrifuge repair 0940

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-16	0900	174	NF	*	7.1	850	420	6.5	6.5	70	400	9.0	7.8	91.8
(Contd)	1000	175	NF	11.5	* [1]	NF	400	NF	NF	NF	390	NF	NF	-
	1100-1800	180	NF	*	* [2]	NF	NF	NF	NF	NF	NF	NF	NF	-
	1900	177	NF	*	7.4	1000	400	13.0	7.0	250	260	9.5	10.0	75.0
	2000	178	NF	1.2	7.4	1000	380	9.5	7.4	230	290	7.5	10.0	77.0
	2100	179	NF	*	7.4	1000	420	10.0	8.0	210	300	8.5	10.0	79.0
	2135			0	Scrubber down; pinch valve ruptured									
11-17	Scrubber Down													
11-18	Scrubber Down													
11-19	1740	174	*	Scrubber start up										
	1800	173	NF	*	* [3]	300	450	13.5	10.0	220	430	13.5	6.8	26.7
	1900	173	NF	*	*	200	440	13.8	7.0	150	420	14.0	7.0	25.0
	2000	182	NF	*	7.3	NF	NF	NF	NF	NF	NF	NF	NF	-
	2100	170	NF	*	*	800	460	14.0	7.0	130	420	13.0	7.6	83.8
	2200	173	NF	9.5	7.1	750	460	14.5	6.8	100	430	14.0	7.8	86.7
	2300	174	NF	*	*	800	460	14.0	6.8	90	400	13.5	8.2	88.8
	2400	174	NF	7.0	6.8	800	460	14.0	6.4	100	400	13.5	8.2	87.5
11-20	0100	174	NF	*	*	800	460	13.5	6.4	150	380	12.5	8.2	81.3
	0200	175	NF	9.2	7.1	800	440	14.0	6.4	120	380	13.0	8.2	85.0
	0300	173	NF	*	*	800	440	14.0	6.2	150	380	13.0	8.0	81.3
	0400	176	NF	*	*	800	440	14.0	6.2	90	380	13.5	8.0	88.8
	0500	174	NF	*	*	800	430	14.0	6.2	90	380	13.5	8.0	88.8
	0600	175	NF	*	*	800	440	14.0	6.2	90	390	13.5	8.2	88.8
	0700	177	NF	*	*	800	430	14.5	6.4	120	400	14.0	8.0	85.0
	0800	175	NF	10.0	7.2	800	440	14.5	6.8	175	400	14.0	7.8	78.1
	0900	174	NF	*	*	950	410	14.5	6.0	110	380	14.1	7.1	88.4
	1000	175	NF	*	6.9	1000	420	15.4	6.0	120	370	15.2	7.2	88.0
	1100	170	NF	*	*	1100	380	20.5	4.0	135	370	18.6	7.2	87.7

[1] Centrifuge diverted 1230 - 1330
[2] Analyzers having flow problems
[3] Faulty solenoid valve on Inlet sampling line

HOURLY DATA

Date	Time	Inlet ACFM x 1000 MW		SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-20 (Contd)	1200	173	NF	8.0	7.1	1100	400	18.5[4]	6.0	140	350	21.3[4]	7.0	87.3
	1300	173	NF	*	7.2	1000	400	12.5	6.0	150	340	8.5	8.2	85.0
	1400	171	NF	8.5	7.1	NF	400	12.0	6.0	NF[1]	380	11.0	7.0	-
	1500	173	NF	*	7.1	1050	410	12.5	5.8	165	400	10.5	7.0	84.3
	1600	180	NF	10.0	7.1	1050	450	12.0	5.5	140	410	11.5	7.2	86.7
	1700	184	NF	*	7.0	1010	420	12.5	6.4	140	400	9.5	8.4	86.1
	1800	177	NF	*	7.0	1000	420	12.5	6.6	160	400	10.5	7.4	84.0
	1900	180	NF	*2	7.0	NF	420	11.5	6.0	NF	400	10.0	7.0	-
	2000	175	NF	*	7.0	1100	410	12.5	6.2	180	400	11.0	7.2	83.6
	2100	175	NF	*	7.0	1100	410	12.0	6.4	180	400	11.4	7.0	83.6
	2200	175	NF	*	7.0	1100	420	12.5	6.2	170	380	12.8	6.8	84.5
	2300	175	NF	*	7.2	900	400	12.5	6.6	160	390	12.5	7.0	82.2
	2400	175	NF	*3	7.1	NF	*	NF	6.6	NF	*	NF	7.0	-
11-21	0100	173	NF	*4	7.0	1150	420	NF	5.5	190	380	NF	7.8	83.5
	0200	176	NF	7.2	7.0	1100	420	NF	5.5	190	380	NF	7.8	82.7
	0300	174	NF	*	6.8	1100	420	NF	6.0	240	380	NF	7.2	78.2
	0400	172	NF	7.2	6.9	1100	420	11.0	6.0	240	380	10.0	7.0	78.2
	0500	160	NF	*	7.0	1200	390	11.0	6.0	260	340	9.5	6.8	78.3
	0600	160	NF	7.2	7.1	1100	400	9.5	5.8	240	360	10.5	7.0	78.2
	0700	160	NF	*	7.1	1100	400	10.0	6.0	230	380	10.5	7.0	79.1
	0800	162	NF	8.9	7.2	950	410	10.5	6.0	200	370	10.5	7.0	78.9
	0900	183	NF	*	7.2	990	440	10.0	6.6	160	420	11.0	7.0	83.8
	1000	177	NF	10.2	7.1	875	460	10.5	6.6	150	430	11.5	7.2	82.9
	1100	177	NF	*	7.1	875	450	12.0	6.2	155	410	12.0	7.0	82.3
	1200	177	NF	11.7	7.1	900	460	12.0	5.8	160	418	12.5	6.8	82.2
	1300	182	NF	*	7.1	900	460	12.5	6.4	170	430	11.5	6.9	81.1
	1400	178	NF	11.4	7.0	950	450	12.5	6.0	175	430	12.0	6.8	81.6
	1500	175	NF	*	7.0	900	460	12.5	6.0	165	430	11.5	6.8	81.7
	1600	177	NF	10.0	7.0	900	460	12.5	6.0	180	430	11.5	7.0	80.0

[1] SO_2 Analyzer maintenance
[2] SO_2 Analyzer maintenance
[3] SO_2 Analyzer maintenance
[4] CO_2 Analyzer malfunction

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-21	1700	184	NF	*	7.0	900	440	12.0	6.8	180	420	15.5	6.8	80.0
(Contd)	1800	189	NF	9.6	7.0	900	440	12.5	7.0	180	420	12.5	7.0	80.0
	1900	188	NF	*	7.1	920	450	12.5	6.8	185	410	13.0	6.8	79.9
	2000	185	NF	*[1]	7.0	OFF	OFF	OFF	OFF	830	480	13.0	6.4	-
	2100	185	OFF	OFF	OFF	OFF	OFF	OFF	OFF	840	480	13.0	6.4	-
	2200	183	OFF	OFF	OFF	OFF	OFF	OFF	OFF	840	420	12.5	6.4	-
	2300	176	OFF	OFF	OFF	OFF	OFF	OFF	OFF	840	420	13.0	6.4	-
	2400	174	OFF	OFF	OFF	OFF	OFF	OFF	OFF	850	420	13.0	6.4	-
11-22	SCRUBBER DOWN													
11-23	SCRUBBER DOWN - Boiler Down 2300, tube leak													
11-24	0239	Scrubber Start Up												
11-24	0300	148	NF	0.5	7.7	800	380	11.4	6.7	150	340	9.0	8.0	81.3
	0400	150	NF	2.5	7.7	875	440	12.4	6.0	240	400	11.0	6.8	72.6
	0500	149	NF	2.4	7.4	810	440	11.5	6.8	250	420	10.5	7.3	69.1
	0600	147	NF	4.2	7.4	800	440	11.6	6.8	210	420	10.4	7.5	73.8
	0700	148	NF	4.8	7.4	900	460	12.4	5.2	200	440	11.4	6.9	77.8
	0800	147	NF	5.5	7.3	900	460	13.4	5.4	190	480	12.5	6.1	78.9
	0900	*[2]	NF	*	*	850	90	NF	NF	850	440	9.8	7.6	0
	1000-1500	SCRUBBER DOWN												
	1530	178	NF	4.4	7.1	NF[3]	NF	NF	NF	170	380	12.6	7.0	-
	1600	178	153.6	7.0	7.1	900	460	13.5	6.4	160	400	12.4	8.0	82.2
	1700	178	153.6	7.0	7.0	910	460	14.5	5.8	170	420	13.0	7.4	81.3
	1800	178	180.2	8.0	7.0	900	450	13.8	6.2	160	420	12.5	7.0	82.2
	1900	180	218.1	8.0	7.0	900	440	14.0	5.9	160	420	12.8	7.2	82.2
	2000	180	218.1	9.5	7.2	880	440	14.0	5.8	150	440	12.5	7.4	83.0
	2100	169	218.1	10.0	7.2	900	460	13.5	6.0	140	410	13.4	6.8	84.4
	2200	178	218.1	9.4	7.1	900	440	14.0	6.0	160	420	13.0	7.0	82.2
	2300	181	218.1	9.6	7.0	900	430	14.0	6.4	150	420	13.0	7.0	83.3
	2400	156	NF	10.0	7.0	900	430	14.3	6.0	150	395	13.3	6.1	83.3

[1] Trailer sampling outlet only, Scrubber down at 2000
[2] Scrubber down 0855, problem with bushing on screw conveyor
[3] Scrubber start up, Inlet flow problems

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-25	0100	151	207.4	9.0	7.2	910	440	14.6	5.3	170	380	10.5	8.7	81.3
	0200	152	82.9	2.4	7.3	925	430	13.5	6.4	245	340	11.2	8.8	73.5
	0300	151	91.1	2.4	7.3	900	440	13.8	6.4	255	350	11.2	8.9	71.7
	0400	147	91.1	2.4	7.4	900	440	13.8	6.5	255	340	11.0	9.1	71.7
	0500	150	146.4	5.0	7.3	900	440	14.2	5.9	220	380	12.2	8.0	75.6
	0600	153	180.2	7.0	7.2	900	440	14.5	5.7	190	390	12.3	7.6	78.9
	0700	176	173.1	6.8	6.9	900	460	14.0	6.2	190	400	12.4	7.2	78.9
	0800	170	140.0	6.6	-	880	440	12.8	6.2	185	390	11.2	7.8	79.0
	0900	182	165.9	6.5	7.1	900	480	11.8	6.4	190	420	11.0	7.6	80.8
	1000	182	188.4	8.5	7.0	990	480	13.2	6.1	165	420	11.9	7.6	83.3
	1100	183	197.6	8.5	-	880	480	13.5	6.0	175	430	12.2	7.6	80.1
	1200	181	197.6	8.5	7.0	850	480	13.5	6.1	180	420	13.4	7.6	78.8
	1300	183	197.6	8.5	7.1	900	480	13.4	6.2	170	430	13.3	7.6	81.1
	1400	180	197.6	8.5	7.1	820	460	13.5	6.4	165	410	13.2	7.8	79.9
	1500	182	197.6	8.8	7.1	880	450	12.2	6.2	185	420	13.4	7.7	79.0
	1600	182	197.6	9.0	7.2	900	460	13.2	6.5	120	350	7.0[3]	6.0	86.7
	1700	180	197.6	9.1	7.1	860	460	14.0	6.4	150	420	12.4	7.8	82.6
	1800	181	165.9	9.1	7.1	900	460	14.0	6.4	NF[1]	NF	NF	NF	-
	1900	180	NF	9.1	7.0	850	460	13.0	7.0	NF	NF	NF	NF	-
	2000	179	165.9	9.1	7.0	850	460	13.5	6.4	130	420	12.5	7.6	84.7
	2100	181	165.9	9.1	7.0	800	460	13.9	6.6	140	410	12.4	6.6	82.5
	2200	180	165.9	9.1	6.9	775	460	13.8	6.6	150	400	12.0	7.6	80.6
	2300	180	153.6	9.2	7.0	750	460	13.8	6.6	160	400	12.0	8.0	78.7
	2400	173	159.7	8.8	7.0	810	440	13.4	6.6	120	400	12.2	7.8	85.2
11-26	0100	180	159.7	9.0	7.1	900	470	13.4	6.8	140	420	12.2	7.8	84.4
	0200	180	159.7	9.0	7.1	900	470	13.0	6.9	140	420	12.0	8.0	84.4
	0300	181	159.7	10.0	7.1	900	460	13.0	6.9	120	440	11.9	7.8	86.7
	0400	175	165.9	9.5	7.1	900	440	13.6	6.5	140	410	11.9	7.9	84.4
	0500	175	165.9	9.5	7.1	875	450	13.4	6.8	150	400	12.4	7.7	82.9
	0600	169	165.9	9.5	7.1	900	450	13.0	6.8	135	410	12.0	7.9	85.0
	0700	180	165.9	9.0	7.3	NF[2]	NF	NF	NF	110	430	12.0	8.0	-
	0800	179	165.9	9.0	7.2	NF	NF	NF	NF	120	430	12.4	7.8	-

[1] Probe cleaned
[2] Restriction in sample line
[3] CO_2 Analyzer malfunction

HOURLY DATA

Date	Time	MW	Inlet ACFM X 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-26	0900	182	165.9	9.0	7.2	NF	NF	NF	NF	150	440	12.3	7.9	-
(Contd)	1000	181	165.9	9.0	7.1	900	460	14.4	6.2	150	440	12.4	7.9	83.3
	1100	179	159.7	9.0	7.0	900	450	13.4	6.8	170	420	12.4	7.9	81.1
	1200	180	165.9	9.0	7.0	900	450	13.3	6.6	150	430	12.4	7.9	83.3
	1300	181	NF	*[1]	*	NF	NF	NF	NF	140	430	12.6	7.8	-
	1400	179	165.9	9.4	6.8	900	450	13.6	6.2	145	430	12.6	7.9	84.6
	1500	182	159.7	9.2	7.0	900	460	13.6	6.8	165	420	12.7	7.6	81.7
	1600	182	159.7	8.9	7.0	1000	460	13.7	6.8	182	430	12.8	7.6	81.8
	1700	182	159.7	8.9	6.9	1000	460	13.8	6.4	155	420	12.8	7.6	84.5
	1800	182	165.9	9.0	7.0	950	490	13.6	6.8	165	430	12.8	7.9	82.6
	1900	182	173.1	9.2	7.0	1000	480	13.0	6.6	180	440	12.5	7.9	82.0
	2000	180	165.9	9.0	7.0	1000	480	14.0	6.7	195	420	13.0	7.9	80.5
	2100	179	159.7	8.6	7.0	1000	500	14.2	6.7	185	450	13.3	7.7	81.5
	2200	179	159.7	9.0	7.0	760	440	14.8	6.9	120	420	13.7	-	84.2
	2300	181	165.9	9.0	7.0	800	450	13.4	6.8	145	430	13.4	7.8	81.9
	2400	179	165.9	9.0	7.0	800	440	14.2	6.6	145	420	12.8	7.8	81.9
11-27	0100	182	NF[2]	9.0	6.9	NF[2]	NF	NF	NF	NF	NF	NF	NF	-
	0200	182	401.4	9.0	7.0	980	460	14.2	6.8	145	430	13.1	7.6	85.2
	0300	178	401.4	9.0	7.1	900	430	12.6	6.8	130	400	11.8	7.8	85.6
	0400	183	401.4	9.0	7.1	875	430	12.5	6.8	120	400	11.8	7.6	86.3
	0500-1200	180	NF[3]	9.0	7.1	NF[3]	NF	NF	NF	NF	NF	NF	NF	-
	1300	178	159.7	9.0	7.1	NF[4]	NF	NF	NF	160	400	12.4	NF	-
	1400	178	153.6	9.0	7.0	NF	NF	NF	NF	173	NF	12.4	NF	-
	1500	176	159.7	9.0	7.0	NF	NF	NF	NF	170	NF	12.5	NF	-
	1600	181	153.6	9.0	7.1	NF[5]	NF	NF	NF	170	NF	12.6	NF	-
	1700	177	146.4	9.0	*	NF	NF	NF	NF	170	NF	12.0	NF	-

[1] Outlet SO_2 Wet testing
[2] Clean sample lines
[3] Pump out on trailer sampling system
[4] Insufficient flow for inlet, NO_x and O_2 readings
[5] Coal feeder problems

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
11-28	NO DATA TAKEN - THANKSGIVING HOLIDAY													
11-29	NO DATA TAKEN - THANKSGIVING HOLIDAY													
11-30	0900[1]	180	197.6	5.2	6.8	950	420	12.8	6.8	240	390	12.0	8.5	74.7
	1000	175	197.6	6.7	7.4	1000	450	13.1	7.0	240	390	12.0	8.5	76.0
	1100	168	228.4	*	*	970	440	13.4	6.7	220	400	12.0	8.2	77.3
	1200	172	NF[2]	5.5	7.0	900	NF[2]	NF	NF	250	NF	NF	NF	72.2
	1300	182	NF	*	*	NF	NF	13.3	7.0	NF	NF	12.0	8.0	-
	1400	182	NF	6.5	7.0	NF	NF	13.5	6.8	NF	NF	12.0	8.0	-
	1500	182	228.4	6.8	7.0	1000	440	13.0	7.0	150	410	11.0	8.0	85.0
	1600	181	218.1	6.4	7.1	1010	450	12.9	7.0	160	410	11.0	8.0	84.2
	1700	176	242.2	6.8	6.9	1000	460	13.5	6.9	165	410	12.0	7.5	83.5
	1800	176	242.2	6.7	7.0	1000	460	13.5	6.7	170	410	12.1	7.8	83.0
	1900	178	228.4	6.6	7.0	1000	420	13.5	6.8	185	400	12.0	8.0	81.5
	2000	178	242.2	6.8	7.0	1010	460	13.3	7.0	185	410	12.1	8.0	81.7
	2100	176	242.2	6.8	7.0	1010	470	13.5	6.7	185	410	12.0	8.0	81.7
	2200	175	NF[2]	*	*	900	450	13.2	6.8	160	410	12.0	7.9	82.2
	2300	175	NF	*[3]	*	900	455	13.2	NF	160	405	12.0	NF	82.2
	2400	176	NF	*	*	900	440	13.3	NF	160	400	12.0	NF	82.2
12-1	0100	177	NF	*	*	900	440	13.2	NF	160	400	12.0	NF	82.2
	0200	172	NF	6.6	7.0	900	400	NF[4]	NF	160	415	NF	NF	82.2
	0300	174	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0400	178	NF	6.5	6.9	NF	NF	NF	NF	NF	NF	NF	NF	-
	0500	174	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0600	178	NF	6.5	7.0	NF	NF	NF	NF	NF	NF	NF	NF	-
	0700	179	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0800	177	NF	6.5	7.0	NF	NF	NF	NF	NF	NF	NF	NF	-
	0900	179	215	*	*	1000	440	12.9	6.6	200	400	11.9	8.1	80.0
	1000	177	215	6.5	7.0	1000	440	13.4	6.5	200	400	11.8	7.9	80.0
	1100	176	NF	*	*	900	480	12.6	6.4	200	405	11.4	7.5	77.8
	1200	179	NF	6.5	7.1	900	460	12.6	6.3	200	405	11.4	7.5	77.8

[1] Began at 0900 after holiday
[2] Flow problems
[3] O_2 Recorder down
[4] Flow problems until 0900

HOURLY DATA

Date	Time	MW	Inlet ACFM X 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-1	1300	179	NF	*	*	900	450	12.3	6.3	200	405	11.2	7.6	77.8
(Contd)	1400	179	NF	6.5	7.1	900	450	12.3	6.3	260	400	11.1	7.6	71.1
	1500	168	NF	*	*	900	440	12.6	6.2	180	400	11.1	7.3	80.0
	1600	180	NF	6.6	7.1	900	440	12.6	6.2	200	390	10.8	7.6	77.8
	1700	178	NF	*	*	900	450	12.5	6.3	210	405	11.3	7.4	76.7
	1800	178	NF	6.2	7.1	900	440	12.3	6.3	210	400	11.1	7.5	76.7
	1900	176	NF	*	*	900	435	12.3	6.2	210	400	11.1	7.5	76.7
	2000	177	NF	5.4	7.1	900	450	12.0	6.5	210	400	10.6	7.7	76.7
	2050	183	NF	*[1]	*	900	500	12.2	>10.0	210	400	NF	6.3	76.7
12-2	SCRUBBER DOWN													
12-3	SCRUBBER DOWN													
12-4	SCRUBBER DOWN													
12-5	1700[2]	165	51.2	0.8	7.1	900	430	14.8	7.0	230	385	13.0	8.5	74.4
	1800	167	56.3	0.8	7.1	950	420	14.9	7.2	228	380	13.1	8.4	76.0
	1900	173	58.9	2.8	7.2	940	425	14.3	7.4	250	410	12.5	7.8	73.4
	2000	175	110.1	2.8	7.1	910	430	14.4	7.2	250	420	13.5	7.9	72.5
	2100	175	110.1	4.5	7.2	950	425	15.0	6.8	220	420	15.4	7.0	76.8
	2200	174	105.0	3.3	7.2	950	440	15.0	5.8	280	420	15.0	5.8	70.5
	2300	177	179.2	5.2	7.1	900	425	15.3	6.0	230	440	15.0	7.1	74.4
	2400	175	165.9	4.8	7.2	950	460	15.2	6.6	230	400	13.5	8.2	75.8
12-6	0100	179	179.2	5.0	7.0	950	420	15.0	6.0	220	380	13.0	8.6	76.8
	0200	182	179.2	5.0	7.0	1000	430	14.8	6.0	220	400	13.0	8.6	78.0
	0300	178	179.2	5.0	7.0	1000	420	15.2	6.2	230	380	12.0	9.0	77.0
	0400	176	179.2	5.0	6.9	1000	420	14.5	5.6	240	400	14.0	7.4	76.0
	0500	176	117.8	4.0	7.2	950	400	15.0	7.2	230	340	12.0	9.6	75.8
	0600	178	179.2	4.5	7.2	1000	420	15.2	6.4	225	350	13.0	9.0	77.5
	0700	178	230.4	4.0	7.2	900	400	15.0	6.6	160	360	14.0	9.0	82.2
	0800	180	197.1	6.3	7.0	900	440	15.0	6.6	155	400	14.0	8.8	82.8
	0900	180	240.6	8.2	7.0	990	460	13.8	6.8	210	410	12.5	8.0	78.8
	1000	180	240.6	8.0	7.0	990	460	13.8	6.8	170	450	13.5	7.4	82.8
	1100	180	240.6	8.0	7.0	900	470	13.7	6.9	160	460	13.5	7.5	82.2
	1200	180	230.4	8.0	7.0	930	390	13.6	7.0	145	360	12.5	8.0	84.4
	1300	178	240.6	8.5	7.1	1000	460	14.5	6.8	450	420	13.5	7.3	55.0

[1] Scrubber down 2050, leak in scrubber bleed lines
[2] Scrubber start up

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-6	1400	179	240.6	8.5	7.0	1000	460	14.5	6.8	NF[1]	NF	NF	NF	-
(contd)	1500	175	207.4	8.5	7.1	1000	460	14.3	6.8	150	420	12.5	8.0	85.0
	1600	180	197.6	8.5	7.1	1000	450	13.8	6.8	170	410	12.6	7.8	83.0
	1700	178	165.9	8.8	7.0	1000	460	14.2	6.6	168	420	12.5	8.0	83.2
	1800	178	188.4	9.0	7.0	1000	460	14.0	6.6	200	415	12.5	8.0	80.0
	1900	172	180.2	8.5	7.0	1000	460	13.8	6.8	208	410	13.0	7.8	79.2
	2000	179	180.2	8.5	7.1	1000	460	14.0	6.6	165	420	12.6	7.8	83.5
	2100	178	180.2	8.9	7.1	1000	460	14.2	6.5	160	420	12.1	7.6	84.0
	2200	176	188.4	8.5	7.1	800	430	14.3	6.6	170	400	13.0	7.8	78.8
	2300	177	188.4	8.6	7.1	880	440	14.0	6.6	180	410	12.7	7.8	79.5
	2400	179	188.4	8.5	7.1	850	440	14.0	6.6	180	410	13.0	7.8	78.8
12-7	0100	177	288.4	9.0	7.1	850	440	14.0	6.4	170	420	13.0	7.8	80.0
	0200	170	228.4	9.0	7.1	900	430	14.0	6.4	175	390	13.0	7.8	80.6
	0300	170	228.4	9.0	7.1	920	430	13.5	6.4	190	400	12.5	8.0	79.3
	0400	170	228.4	9.0	7.1	900	440	14.0	6.4	175	400	12.5	7.8	80.6
	0500	170	228.4	9.5	7.1	900	440	13.5	6.6	180	420	12.5	7.6	80.0
	0600	170	228.4	9.5	7.2	900	440	13.5	6.6	180	420	12.5	7.6	80.0
	0700	170	228.4	9.5	7.2	900	440	13.5	6.4	170	410	12.7	7.6	81.1
	0800	173	207.4	9.5	7.2	800	440	14.0	6.6	150	420	12.8	7.6	81.3
	0900	173	207.4	9.5	7.1	900	460	14.0	6.5	150	430	12.8	7.6	83.3
	1000	176	207.4	9.5	7.1	860	440	13.5	6.8	150	410	12.8	7.6	82.6
	1100	179	135.7	7.0	7.0	800	420	13.5	6.8	150	400	12.5	7.8	81.3
	1200[2]	179	140.8	3.0	7.5	890	420	13.3	7.0	230	400	12.2	8.3	74.2
	1300	179	146.4	5.0	7.4	11.40	NF	NF	NF	252	380	13.0	8.2	77.9
	1400	179	173.1	7.5	7.3	875	420	14.5	6.7	120	390	12.5	8.2	86.3
	1500	175	*3	*[3]	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1600	180	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1700	177	188.4	8.6	7.0	960	425	13.4	6.8	210	380	12.2	7.4	78.1
	1800	177	188.4	8.8	7.1	1020	440	12.9	6.7	190	400	11.8	7.4	81.4
	1900	178	188.4	8.6	7.1	980	440	13.1	6.6	145	400	12.0	7.3	85.2
	2000	179	188.4	8.6	7.1	1020	430	12.9	6.6	115	400	12.2	7.4	88.7
	2100	177	197.6	8.6	7.0	1020	440	12.7	6.6	135	395	12.4	7.2	86.8

[1] Outlet probe cleaned
[2] 1st Stage outage, leak in recycle header
[3] Pump outage on sampling system

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-7	2200	175	188.4	8.8	7.0	1000	460	13.0	6.4	140	400	12.3	7.4	86.0
(contd)	2300	176	188.4	8.6	6.9	1000	450	13.1	6.4	145	400	11.8	7.4	85.5
	2400	179	188.4	8.6	7.0	1000	440	13.0	6.2	140	400	12.0	7.2	86.0
12-8	0100	181	188.4	8.5	7.0	900	440	13.0	6.6	140	400	12.5	7.4	84.4
	0200	179	188.4	*[1]	*	1000	450	13.0	6.6	NF	NF	NF	NF	-
	0300	179	NF	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0400	180	188.4	8.5	7.1	1000	440	13.0	6.2	150	330	12.0	7.6	85.0
	0500	180	188.4	8.5	7.0	1000	450	13.0	6.2	150	400	12.0	7.6	85.0
	0600[2]	180	188.4	8.5	7.0	1000	480	13.0	6.2	135	440	12.0	7.6	86.5
	0700	179	188.4	8.5	6.9	950	480	13.0	6.2	140	440	12.5	7.4	85.3
	0800	177	188.4	8.5	6.8	1000	460	13.2	6.2	180	400	12.2	7.0	82.0
	0900	146	188.4	8.3	6.7	1200	410	13.0	6.2	200	400	12.2	7.2	83.3
	1000	144	180.2	8.1	6.9	1100	400	13.0	6.0	200	360	12.0	7.0	81.8
	1100	143	180.2	8.1	6.9	1200	400	12.6	5.8	200	360	12.0	7.0	83.3
	1200	137	173.1	7.3	6.9	1100	420	12.5	5.8	220	360	12.5	6.8	80.0
	1300	129	165.9	6.0	6.9	1200	420	13.0	6.4	240	380	12.0	7.0	80.0
	1400	110	165.9	6.2	6.9	1100	420	NF	NF	220	360	12.7	6.8	80.0
	1500	111	146.4	3.5	6.9	1100	400	12.5	6.5	240	360	12.3	8.0	78.2
	1600	106	146.4	3.5	7.2	1050	400	12.7	7.0	250	340	11.6	8.4	76.2
	1700	102	153.6	3.8	7.0	1050	410	13.0	6.2	250	380	10.5	8.9	76.2
	1800	103	153.6	5.6	7.0	1020	420	12.0	7.8	260	400	10.6	9.0	74.5
	1900	96	180.2	3.8	7.0	1020	445	12.7	7.0	260	400	10.5	8.9	74.5
	2000	97	188.4	3.9	7.1	1020	430	12.8	6.4	270	390	11.1	8.4	73.5
	2100	102	188.4	3.9	7.1	1100	420	11.7	7.2	280	390	10.0	9.0	74.5
	2200	102	188.4	3.5	7.2	1000	400	12.7	6.6	240	380	11.3	8.4	76.0
	2300	100	188.4	3.8	7.2	1050	380	11.5	8.0	280	360	11.4	8.4	73.3
	2400	102	188.4	4.0	7.0	1100	410	13.0	6.4	290	360	11.5	8.0	73.6
12-9	0100	101	188.4	4.2	7.0	1200	440	13.0	6.0	290	400	12.2	7.4	75.8
	0200	101	188.4	4.4	7.0	1200	440	13.0	6.4	280	400	12.5	7.6	76.7
	0300	101	188.4	4.4	7.0	1200	440	13.0	6.6	290	400	12.0	7.8	75.8
	0400	101	188.4	4.4	7.0	1200	420	13.0	6.6	280	380	11.7	7.8	76.7

[1] Outlet probe blocked
[2] Drop in load, wet coal

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-9	0500	110	188.4	4.2	7.0	1200	400	13.0	6.4	310	380	12.5	7.2	74.2
(contd)	0600	101	188.4	4.4	7.0	1200	440	12.0	7.0	310	380	13.0	6.9	74.2
	0700[1]	100	188.4	4.4	7.1	1200	400	13.0	7.0	320	360	11.5	8.4	73.3
	0800	99	188.4	4.3	7.1	1050	420	13.0	6.8	220	380	12.5	7.3	79.0
	0900	161	197.6	4.5	7.1	1100	380	13.2	6.4	230	320	12.5	6.8	79.1
	1000	185	197.6	4.5	7.0	900	420	12.5	7.2	220	370	11.0	8.7	75.6
	1100	185	197.6	4.3	6.9	850	400	12.5	7.3	185	360	12.2	8.4	78.2
	1200	185	218.1	4.7	6.9	850	410	12.8	6.6	175	380	11.5	8.4	79.4
	1300	165	218.1	5.8	6.8	920	460	12.5	7.0	190	420	12.0	8.0	79.3
	1400	170	218.1	5.8	7.0	900	460	12.8	6.6	185	400	13.0	6.8	79.4
	1500	172	207.4	5.1	7.1	900	460	13.0	6.4	200	400	12.8	6.9	77.8
	1600	169	207.4	4.0	7.1	900	445	12.7	6.6	195	370	11.0	8.2	78.3
	1700	182	207.4	5.8	7.0	900	440	12.9	6.6	175	400	11.2	8.0	80.6
	1800	190	218.1	5.7	6.9	900	430	13.3	6.4	190	400	11.8	7.7	78.9
	1900	189	228.4	6.2	7.0	950	410	13.6	6.4	180	380	11.9	7.8	81.1
	2000	193	218.1	6.0	7.0	900	420	13.4	6.4	220	380	11.6	8.2	75.6
	2100	182	228.4	6.0	6.9	920	420	13.2	6.4	225	370	12.1	7.6	75.5
	2200	183	228.4	6.2	6.9	950	400	13.5	6.4	280	360	12.0	7.4	70.5
	2300	175	228.4	6.2	6.9	980	420	13.8	6.0	290	390	12.5	7.2	70.4
	2400	173	228.4	5.8	7.2	980	420	12.5	6.8	180	380	12.0	7.6	81.6
12-10	0100	176	228.4	6.0	7.1	1000	400	14.0	5.2	190	380	12.0	7.8	81.0
	0200	174	228.4	6.0	7.0	950	360	13.5	6.4	220	350	12.5	7.5	76.8
	0300	164	228.4	6.0	6.8	1000	400	14.0	5.8	230	380	12.5	7.5	77.0
	0400	148	242.2	7.0	6.9	900	400	13.5	6.2	240	370	13.0	6.8	73.3
	0500	147	228.4	7.0	6.9	850	380	12.5	7.5	220	360	11.0	8.8	74.1
	0600	170	228.4	6.5	6.9	800	380	13.5	6.5	200	340	13.0	7.4	75.0
	0700	156	228.4	7.0	7.0	800	380	13.5	6.5	200	340	12.5	7.6	75.0
	0800	151	228.4	6.8	7.1	800	400	14.3	6.0	170	360	12.0	7.8	78.8
	0900	178	228.4	5.4	7.1	800	420	14.3	6.4	150	370	12.3	7.8	81.3
	1000	183	228.4	4.8	6.9	800	410	13.7	6.8	200	380	12.3	7.8	75.0
	1100	184	218.1	3.8	6.2	800	400	14.3	6.2	240	380	12.0	8.0	70.0
	1200	180	173.1	2.2	7.2	800	400	12.7	7.0	230	320	10.0	>10.0	71.3

[1] Rising Boiler load

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-10	1300-1600	175	NF	*[1]	7.3	NF	NF	NF	NF	NF	NF	NF	NF	-
(contd)	1700	176	207.4	4.4	7.1	980	440	13.4	6.2	225	390	10.0	8.9	77.0
	1800	176	207.4	4.0	6.9	1020	430	13.3	6.6	230	360	12.3	7.8	77.5
	1900	178	207.4	4.0	7.0	1050	420	12.4	7.0	235	350	11.2	8.6	77.6
	2000	177	207.4	4.2	7.0	1090	400	13.0	6.8	240	360	11.4	8.7	78.0
	2100	177	218.1	4.4	7.0	1100	400	13.3	6.2	245	360	12.3	7.8	77.7
	2200	166	228.4	5.5	7.0	1120	510	14.5	5.4	260	370	12.6	7.6	76.8
	2300	168	228.4	5.6	7.0	1100	400	13.1	6.3	220	360	12.1	7.7	81.8
	2400	153	228.4	6.0	7.0	1100	380	13.5	6.0	220	360	12.0	7.8	81.8
12-11	0100	164	242.2	6.0	7.0	1100	400	13.5	6.0	220	360	12.0	7.8	81.8
	0200	162	242.2	6.0	6.9	1100	400	13.2	6.2	240	390	13.5	6.6	78.2
	0300	162	242.2	6.0	6.9	1100	400	13.5	6.2	220	390	12.5	7.2	81.8
	0400[2]	163	180.2	1.0	7.2	1100	410	13.0	7.0	240	360	12.0	8.4	78.2
	0500[3]	163	180.2	0	7.1	1100	300	11.0	9.0	>1000	420	12.5	7.0	-
12-12	1300[4]	170	197.6	4.0	7.2	1200	380	14.6	6.5	305	360	16.1	5.6	74.6
	1400	172	197.6	0	7.1	NF[5]	NF	NF	NF	308	360	10.9	6.7	-
12-13	1810[6]	120	228.4	1.4	7.2	1250	395	15.0	5.0	55	90	3.2	>10.0	95.6
	1900	118	228.4	3.2	7.2	1250	390	14.0	5.7	285	320	11.5	8.8	77.2
	2000	111	242.2	2.7	7.1	1180	390	13.9	5.5	290	320	11.6	8.0	75.4
	2100	116	228.4	2.7	7.1	1200	410	13.3	3.2	275	320	10.7	8.7	77.1
	2200	113	242.2	5.3	6.8	1250	400	13.6	6.2	235	350	13.4	7.6	81.2
	2300	108	242.2	5.0	7.1	1200	420	13.8	6.0	225	380	13.6	7.4	81.3
	2400	107	228.4	5.2	7.1	1100	450	13.4	6.3	210	390	12.6	7.8	80.9

[1] Pump out on sampling apparatus
[2] 1st Stage outage, dropped hammer
[3] Scrubber shut down - 0425
[4] Scrubber start up - 1230
[5] Scrubber shut down - 1420
[6] Scrubber start up - 1810

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-14	0100	102	153.6	5.3	7.2	1100	480	13.0	6.5	200	420	12.5	7.8	81.8
	0200	100	153.6	5.4	7.1	1100	480	13.0	6.7	250	420	12.5	7.8	77.3
	0300	101	153.6	5.4	7.1	1200	480	13.0	6.5	230	420	12.3	7.8	80.8
	0400	102	153.6	5.3	7.0	1200	480	13.0	6.5	230	420	12.3	7.8	80.8
	0500	102	153.6	5.3	7.0	1200	480	13.8	6.5	220	420	13.0	7.6	81.7
	0600	102	153.6	5.3	7.0	1200	480	13.8	6.5	220	420	13.6	7.6	81.7
	0700	102	153.6	5.3	7.1	1200	440	14.0	6.8	210	400	12.9	8.0	82.5
	0800	102	153.6	5.5	7.1	1050	420	14.0	6.5	230	380	13.4	8.0	78.1
	0900	101	159.7	5.5	7.1	1050	420	14.0	7.2	195	360	13.5	8.0	81.4
	1000	103	146.4	6.4	7.2	1080	400	13.6	7.0	200	350	12.5	8.0	81.5
	1100	121	159.7	6.5	7.1	1100	380	13.7	5.8	240	330	14.8	7.2	78.2
	1200	133	159.7	6.5	7.1	1200	370	14.2	5.8	225	330	13.9	7.0	81.3
	1300	135	165.9	6.2	7.1	1120	400	14.8	5.5	185	360	13.0	7.8	83.5
	1400[1]	135	159.7	6.2	7.0	1150	390	14.5	5.7	205	340	13.0	7.3	82.2
	1500	146	153.6	6.0	7.0	1060	400	13.0	6.4	195	345	12.0	7.4	81.6
	1600	140	120.3	2.4	7.1	1000	400	13.0	6.4	245	360	12.6	7.0	75.5
	1700	144	153.6	*[2]	*	1100	400	13.0	8.0	NF	NF	NF	NF	-
	1800	147	153.6	*	*	900	NF	NF	NF	200	300	13.0	7.0	77.8
12-15	0100	140	165.9	7.2	7.1	900	380	13.2	6.5	160	320	12.0	7.8	82.2
	0200-1300	*[3]	*	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1400	175	159.7	6.7	7.0	1050	450	14.2	7.0	210	390	13.2	8.0	80.0
	1500	176	159.7	6.5	7.0	980	450	14.3	6.9	200	400	12.2	8.4	79.6
	1600	178	140.8	6.5	6.9	900	440	14.0	7.0	200	390	13.0	8.4	77.8
	1700	179	188.4	6.5	7.0	1000	440	14.0	6.8	210	400	13.0	8.0	79.0
	1800	176	197.6	8.2	7.0	1100	440	14.5	6.8	240	380	13.5	8.0	78.2
	1900	178	197.6	7.3	7.0	900	420	14.0	7.0	200	390	11.5	8.0	77.8
	2000	135	140.8	6.0	6.8	1100	420	14.5	6.8	200	390	11.0	9.0	81.8
	2100	151	140.8	8.0	7.0	1100	400	13.5	6.8	170	360	11.5	8.0	84.5
	2200	168	140.8	7.0	7.0	1100	400	13.5	6.8	170	360	11.5	8.0	84.5
	2300	172	159.7	7.0	7.0	1000	390	14.0	6.8	170	355	11.5	7.9	83.0
	2400	173	159.7	6.7	7.0	1040	390	14.0	6.8	185	360	12.0	8.0	82.2

[1] Variance of I/G
[2] Probe maintenance
[3] Sample line burn-out

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-16	0100	155	159.7	6.5	7.0	1040	390	14.0	6.8	185	360	12.0	8.0	82.2
	0200	172	130.6	6.0	7.1	1040	420	14.8	6.2	200	390	12.6	7.8	80.8
	0300	170	159.7	7.0	7.1	1000	410	14.8	6.8	200	380	12.2	8.4	80.0
	0400	150	153.6	6.2	7.0	1000	380	13.2	7.8	210	340	13.4	7.5	79.0
	0500	155	153.6	6.0	7.1	1000	400	13.8	7.0	190	330	14.2	7.5	81.0
	0600	171	140.8	6.0	7.2	1100	400	14.8	6.4	200	360	13.5	7.8	81.8
	0700	168	146.4	6.0	7.3	1000	400	14.8	6.8	180	330	11.5	8.4	82.0
	0800	160	146.4	6.0	7.3	1000	400	14.0	6.2	150	350	13.0	8.0	85.0
	0900	145	140.8	6.5	7.3	885	380	13.8	5.8	140	340	12.0	7.2	84.2
	1000	143	140.8	6.1	7.3	850	370	13.8	5.7	150	340	12.5	7.2	82.4
	1100	145	153.6	6.3	7.2	800	380	13.7	5.8	175	350	12.7	6.4	78.1
	1200[1]	146	159.7	6.4	7.2	940	370	14.0	5.7	160	350	13.8	6.2	83.0
	1300	146	74.8	0	7.5	890	350	13.6	6.0	685	320	12.9	7.0	23.0
	1400	146	74.8	0	>8	885	345	14.0	6.0	680	320	12.5	6.5	23.2
	1500	143	82.9	0	>8	900	350	13.9	6.0	135	210	9.5	10.8	85.0
	1600[2]	140	74.8	1.8	7.5	770	360	14.0	6.4	150	260	11.0	9.4	80.5
	1700	140	140.8	6.0	7.1	800	360	14.0	6.4	140	260	11.5	7.8	82.5
	1800	140	140.8	5.4	7.1	790	370	12.0	7.3	140	340	13.0	7.2	82.3
	1900	142	165.9	8.2	6.9	780	360	13.5	6.4	140	320	13.0	7.4	82.1
	2000	142	165.9	8.2	6.9	860	360	14.5	6.2	120	330	12.5	7.2	86.0
	2100	140	165.9	8.2	7.0	840	360	12.5	6.4	130	340	11.5	7.2	84.5
	2200	138	165.9	8.3	7.1	800	380	14.0	6.0	140	340	11.7	7.4	82.5
	2300	140	165.9	8.4	7.1	840	380	15.5	5.9	140	325	13.5	7.0	83.3
	2400	145	165.9	8.4	7.1	820	380	12.5	6.5	130	325	12.5	7.8	84.1
12-17	0100	156	159.7	7.8	7.1	820	380	13.4	6.8	120	340	12.5	7.8	85.4
	0200	160	159.7	7.5	7.1	840	380	14.0	6.2	120	340	12.5	8.0	85.7
	0300	160	159.7	7.5	7.2	800	380	13.5	6.5	130	340	12.5	7.5	83.8
	0400	160	159.7	7.5	7.1	800	380	14.5	6.2	130	340	12.5	7.5	83.8
	0500	160	159.7	7.5	7.2	800	380	13.5	6.6	120	340	12.5	7.8	85.0

[1] Scrubber 2nd Stage out for repairs
[2] Coal feeder problems - Unit #3

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-17	0600	160	159.7	7.8	7.2	800	380	13.2	6.8	110	340	12.2	7.8	86.3
(contd)	0700[1]	158	159.7	7.8	7.1	840	380	12.5	6.8	140	340	12.1	7.8	83.3
	0800	145	95.2	3.1	7.3	780	320	13.8	6.2	200	340	13.5	6.0	74.4
	0900[2]	151	130.6	3.7	7.2	790	380	14.0	6.5	165	345	13.9	6.7	79.1
	1000	162	159.7	8.2	7.1	1050	365	11.8	6.4	170	340	11.9	7.8	83.8
	1100	174	159.7	8.7	7.0	950	395	13.0	6.8	135	380	12.3	7.2	85.8
	1200	182	180.2	6.0	7.1	960	470	13.6	6.1	180	440	12.7	7.0	81.3
	1300	182	197.6	8.5	7.1	810	460	12.7	6.5	135	450	12.9	6.7	83.3
	1400	182	180.2	9.7	7.2	790	460	13.5	6.3	110	450	12.7	6.7	86.1
	1500	181	165.9	9.8	7.1	800	460	13.5	6.4	102	410	12.6	7.4	87.3
	1600	182	165.9	10.0	7.1	800	465	14.5	5.9	120	410	13.6	6.4	85.0
	1700	181	180.2	10.1	7.2	840	400	14.0	5.2	110	400	13.0	6.8	86.9
	1800	180	180.2	10.1	7.0	800	420	13.5	5.9	120	390	13.0	5.0	85.0
	1900	181	188.4	10.3	7.1	800	410	14.5	6.0	110	400	13.0	6.4	86.3
	2000	163	197.6	12.0	7.0	800	400	14.5	5.8	120	340	14.0	5.4	85.0
	2100	174	197.6	10.1	7.0	800	405	14.5	5.8	125	380	14.0	6.8	84.4
	2200	180	197.6	10.0	7.1	800	400	14.5	5.8	125	360	13.0	5.2	84.4
	2300	182	188.4	10.1	7.1	900	440	14.0	5.6	100	400	11.5	6.8	88.9
	2400	182	180.2	10.0	7.0	950	400	14.0	5.6	170	380	12.0	6.8	82.1
12-18	0100	174	188.4	10.5	7.0	950	420	14.0	5.4	160	380	13.0	6.6	83.2
	0200	188	188.4	9.8	7.1	930	440	14.2	5.6	150	400	12.7	7.0	83.9
	0300	190	188.4	9.8	7.1	900	460	14.2	5.6	160	400	12.7	6.8	82.2
	0400	190	188.4	9.8	7.1	930	480	14.8	5.6	150	440	13.7	6.5	83.9
	0500[3]	190	138.4	9.8	7.2	900	460	14.4	5.6	138	420	13.5	6.5	84.7
	0600	185	188.4	10.2	7.0	1080	460	14.4	5.6	174	410	14.0	6.5	83.9
	0700	190	138.4	10.5	7.0	1020	450	14.2	5.8	174	380	13.5	6.5	82.9
	0800	172	NF[4]	9.5	7.0	1100	440	15.0	5.0	186	380	15.0	6.6	83.1
	0900	175	NF	9.8	7.1	1020	440	15.5	5.0	168	400	14.0	5.6	83.5
	1000	174	NF	9.8	6.9	1020	440	14.5	5.4	204	390	13.0	6.4	80.0
	1100	174	NF	9.8	6.9	1140	450	14.5	5.4	192	400	13.0	6.4	83.2

[1] Coal feeder problem
[2] Change liquid flow rate
[3] SO_2 readings from DuPont unit
[4] Testing using inlet ports

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-18	1200	174	NF	7.8	7.0	1140	410	12.8	6.8	210	400	12.5	7.2	81.6
(contd)	1300	174	NF	9.0	7.1	1140	460	14.0	5.4	192	400	12.5	6.6	83.2
	1400	174	NF	9.8	7.0	1140	440	14.2	5.4	192	400	13.2	6.4	83.2
	1500	173	NF	9.8	7.0	1200	440	14.5	5.4	192	390	12.5	6.4	84.0
	1600	174	NF	9.8	7.0	1140	440	14.0	5.6	200	400	12.5	6.6	82.5
	1700	173	NF	9.2	7.0	1140	440	14.2	5.5	200	400	12.5	6.8	82.5
	1800	174	NF	9.8	7.0	1140	440	13.5	5.8	200	400	12.5	6.8	82.5
	1900	173	NF	9.0	7.0	1140	440	14.2	5.4	200	400	12.5	6.8	82.5
	2000	171	NF	9.0	7.0	1140	400	14.0	5.8	200	360	13.0	7.0	82.5
	2100	171	NF	8.5	6.9	1140	400	14.2	5.6	200	360	13.0	7.0	82.5
	2200	172	NF	8.0	7.0	1140	400	14.0	5.9	200	360	13.2	6.8	82.5
	2300	172	NF	8.0	7.0	1140	400	14.0	5.6	210	360	12.3	7.0	81.6
	2400	167	NF	8.2	6.9	1140	400	13.7	6.0	192	360	13.0	6.8	83.2
12-19	0100[1]	166	188.4	8.2	6.9	1140	400	14.5	5.4	192	380	12.0	7.0	83.2
	0200	166	188.4	8.2	7.0	1140	400	14.3	5.5	192	360	12.0	7.0	83.2
	0300	166	188.4	8.2	7.0	1140	400	14.3	5.6	192	360	12.0	6.8	83.2
	0400	160	188.4	8.5	7.0	1260	450	14.5	5.5	210	390	12.6	6.8	83.3
	0500	162	188.4	8.5	6.9	1140	430	14.1	5.4	204	380	12.9	6.8	82.1
	0600	162	188.4	8.5	7.0	1080	440	14.0	6.0	192	380	13.2	6.8	82.2
	0700	158	197.6	8.5	7.0	1080	420	14.5	5.8	210	360	12.5	6.8	80.6
	0800[2]	157	197.6	8.5	7.0	1200	400	14.3	5.8	234	360	12.5	6.8	80.5
	0900	157	207.4	8.4	7.0	1200	420	15.0	5.8	230	360	12.0	7.2	80.8
	1000	157	159.7	*	*	1200	460	15.0	5.8	300	360	11.5	8.0	75.0
	1100	156	165.9	*	*	1200	450	13.5	6.2	300	350	12.0	8.0	75.0
	1200	152	165.9	*	*	1200	440	14.0	6.0	300	340	11.0	8.0	75.0
	1300-1500	SCRUBBER DOWN - 2nd Stage recycle header had to be repaired												
	1600[3]	143	173.1	2.8	7.0	1200	440	13.5	5.8	300	390	12.5	7.0	75.0
	1700	150	188.4	6.0	7.1	1300	420	12.0	6.0	220	370	11.0	7.6	83.1
	1800	143	197.6	6.2	7.1	1200	430	15.0	5.0	228	380	13.0	7.0	81.0

[1] SO_2 readings from DuPont unit
[2] 2nd Stage outage (for repairs)
[3] Scrubber start up

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-19	1900	146	197.6	6.4	7.1	1320	400	14.0	6.0	216	330	13.0	7.0	83.6
(contd)	2000	146	197.6	6.4	7.1	1320	420	12.5	5.8	240	370	11.5	7.0	81.8
	2100	145	197.6	6.0	7.1	1200	400	13.0	5.8	238	340	11.7	7.0	80.2
	2200	149	197.6	6.0	7.1	1280	400	12.5	6.0	240	360	11.5	7.4	81.3
	2300	145	197.6	6.4	7.0	1260	420	13.5	6.1	240	360	12.5	7.0	81.0
	2400	129	197.6	3.4	7.1	1200	450	12.8	5.7	240	350	11.6	8.0	80.0
12-20	0100[1]	100	197.6	3.6	7.2	1140	450	12.4	6.0	252	370	11.8	7.5	77.9
	0200	100	207.4	3.7	7.1	1140	430	12.3	5.2	252	405	10.7	6.8	77.9
	0300	100	207.4	3.9	7.0	1180	490	12.5	5.9	282	415	11.5	7.0	76.1
	0400	100	207.4	3.5	7.0	1200	490	12.4	5.9	282	415	11.3	6.9	76.5
	0500	100	105.0	3.8	7.0	1140	425	12.8	6.2	252	370	11.2	7.5	77.9
	0600[2]	90	105.0	3.5	7.0	1080	390	NF	7.2	255	350	NF	8.5	76.4
	0700	90	99.3	3.5	7.0	1180	460	NF[3]	6.3	280	380	NF	7.5	76.3
	0800	99	91.1	3.4	7.0	1200	430	NF	7.2	285	350	NF	8.1	76.3
	0900	98	99.3	3.6	7.0	1180	460	13.5	6.2	240	360	13.0	8.1	79.7
	1000	94	NF	3.6	7.0	1180	470	13.4	6.8	240	370	12.2	7.8	79.7
	1100	88	NF	3.6	7.0	1020	400	12.5	7.0	200	400	11.5	8.2	80.4
	1200	90	NF	3.8	7.2	960	480	12.5	6.4	186	410	11.0	8.2	80.6
	1300	89	NF	3.8	7.2	960	440	13.0	6.2	192	390	11.5	8.0	80.0
	1400	91	NF	3.8	7.2	960	500	13.5	7.1	192	420	12.5	7.3	80.0
	1500	89	NF	3.8	7.1	930	480	15.0	6.0	198	420	14.0	6.3	78.7
	1600[4]	95	NF	3.8	7.0	840	480	12.5	6.1	190	400	11.5	7.8	77.4
	1700	102	NF	3.8	7.0	960	480	14.0	6.0	210	410	12.5	7.5	78.1
	1800	102	NF	3.2	7.0	840	470	13.0	6.0	200	360	12.0	7.2	76.2
	1900	106	NF	3.0	7.0	1000	460	13.0	6.1	240	370	11.0	8.0	76.0
	2000	115	95.2	3.0	7.0	980	400	12.5	6.2	200	340	11.0	8.0	79.6
	2100	124	95.2	3.0	7.1	1020	380	13.0	6.0	200	340	11.0	8.0	80.4
	2200	128	99.3	2.8	7.1	980	380	12.5	6.0	230	320	11.0	8.1	76.5
	2300	126	95.2	3.0	7.1	980	380	12.5	6.0	240	320	11.5	7.6	75.5

[1] SO_2 readings from DuPont unit
[2] CO_2 Analyzer not working
[3] Boiler feed problem wet coal
[4] SO_2 readings from TECO unit resumed

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-20 (contd)	2400	130	82.9	2.8	7.1	720	380	12.5	6.2	190	340	11.5	7.5	73.6
12-21	0100	129	105.0	4.5	7.0	820	380	12.6	7.3	170	340	11.8	7.3	79.3
	0200	131	115.2	4.5	7.0	800	375	12.9	6.3	160	335	11.7	7.4	80.0
	0300	131	130.6	5.8	7.0	840	420	13.9	6.3	190	365	12.5	7.8	77.4
	0400	133	135.7	6.2	6.9	960	405	13.5	6.4	140	380	12.4	7.6	85.4
	0500	125	135.7	5.8	7.0	950	420	13.5	6.8	160	375	12.3	7.5	83.2
	0600	122	130.6	5.5	7.1	940	390	14.1	5.8	150	350	12.0	7.6	84.0
	0700	130	125.4	5.5	7.1	920	370	14.4	5.7	160	350	12.5	7.8	82.6
	0800	129	140.8	6.4	7.1	860	375	13.5	6.0	110	320	11.0	8.4	87.2
	0900	131	140.8	5.4	7.0	860	400	12.6	6.4	120	364	12.0	7.2	86.0
	1000	131	NF	6.6	7.0	980	400	13.5	6.1	160	360	12.5	7.2	83.7
	1100	131	NF	6.6	7.0	1000	400	13.5	6.4	160	360	12.5	7.0	84.0
	1200	131	NF	6.6	6.8	1160	390	12.5	6.4	140	350	12.5	7.0	87.9
	1300	132	NF	6.6	6.9	1180	390	13.0	6.2	200	300	13.0	7.4	83.1
	1400	132	NF	6.6	6.9	1160	300	14.5	6.2	200	260	13.5	7.6	82.8
	1500	132	NF	6.8	6.9	1220	390	14.5	5.8	420	260	14.0	5.2	65.6
	1600	132	NF	6.4	7.1	1000	300	13.0	6.1	240	260	12.0	7.2	76.0
	1700	138	NF	6.4	7.1	1000	300	13.0	6.1	240	260	12.5	7.2	76.0
	1800	141	NF	6.4	7.1	1000	300	13.0	5.9	280	260	11.5	7.2	72.0
	1900	144	125.4	6.4	7.1	920	300	13.0	6.0	180	260	12.0	7.0	80.4
	2000	144	125.4	6.4	7.1	1080	280	13.0	5.8	200	240	12.5	7.0	81.5
	2100	146	125.4	6.4	7.0	1080	250	13.0	5.8	220	230	12.0	7.1	79.6
	2200	147	125.4	6.4	7.1	1080	250	14.0	5.4	200	220	13.0	7.0	81.5
	2300	147	130.6	6.4	7.0	1080	230	14.0	5.6	200	210	13.0	7.0	81.5
	2400	148	135.7	6.5	7.2	920	230	14.3	5.4	150	195	12.7	6.8	83.7
12-22	0100	149	130.6	6.7	7.2	900	220	13.3	6.0	140	195	12.5	7.0	84.4
	0200	137	140.8	6.5	7.1	900	215	16.4	5.4	120	190	13.8	7.7	86.7
	0300	113	140.8	6.7	7.2	1100	445	14.5	6.0	220	400	13.3	7.3	80.0
	0400	111	140.8	6.7	7.2	1100	430	14.7	6.7	210	370	13.8	7.3	80.9
	0500	115	140.8	6.3	7.2	940	370	13.7	6.6	190	360	12.7	8.3	79.8
	0600	111	135.7	6.5	7.1	1080	390	14.0	6.7	220	340	12.5	8.4	79.6
	0700	110	135.7	6.8	7.1	1000	380	14.3	6.6	260	360	13.4	7.5	74.0

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-22	0800[1]	136	135.7	6.2	7.1	980	400	14.0	6.0	180	360	12.5	7.6	81.6
(contd)	0900-1000	SCRUBBER OUT												
	1100[2]	174	140.8	6.2	7.2	890	440	12.5	6.8	128	390	12.6	8.1	85.6
	1200	173	140.8	6.3	7.2	800	440	12.5	6.8	140	390	12.6	8.1	82.5
	1300	174	140.8	6.3	7.2	800	400	13.5	6.5	200	380	13.0	8.0	75.0
	1400	175	146.4	7.0	7.1	880	440	14.5	6.4	200	380	12.5	8.0	77.3
	1500	176	146.4	6.2	7.2	800	440	13.0	6.8	200	380	13.5	8.0	75.0
	1600	176	146.4	6.6	7.1	800	440	12.5	6.8	100	380	11.5	8.1	80.0
	1700	177	146.4	7.0	7.1	760	420	12.5	7.0	160	380	11.0	8.5	78.9
	1800	174	140.8	6.8	7.1	800	420	12.5	7.0	160	360	11.5	8.2	80.0
	1900	179	140.8	6.4	7.1	880	400	13.0	7.0	200	360	11.5	8.1	77.3
	2000	181	140.8	6.4	7.2	880	400	13.0	7.0	200	360	11.0	8.5	77.3
	2100	180	135.7	6.4	7.2	930	420	13.0	7.0	220	360	11.0	8.6	76.3
	2200	178	140.8	6.4	7.1	840	400	13.0	7.0	200	360	12.0	8.4	76.2
	2300	176	140.8	6.4	7.1	880	400	13.0	6.8	210	360	11.5	8.2	76.1
	2400	160	165.9	8.3	7.0	840	400	13.0	6.9	140	360	12.0	8.2	83.3
12-23	0100	141	NF[3]	8.8	6.9	NF[3]	NF	NF	NF	NF	NF	NF	NF	-
	0200	116	180.2	9.2	6.9	780	400	13.0	7.3	150	380	12.0	8.4	80.7
	0300	108	180.2	9.2	7.0	840	400	13.5	7.2	150	380	12.0	8.2	82.1
	0400	108	188.4	9.2	7.0	800	405	13.0	7.2	100	380	12.4	8.2	80.0
	0500	109	180.2	9.2	7.0	810	400	13.5	7.2	140	375	12.5	8.0	82.7
	0600	110	180.2	8.8	7.0	850	385	12.6	8.0	160	340	12.0	8.4	81.2
	0700	119	180.2	9.0	7.0	1000	380	13.0	7.0	160	340	13.0	7.0	84.0
	0800[4]	140	173.1	8.0	7.0	880	360	12.5	6.8	160	320	12.0	7.8	81.8
	0900[4]	169	146.4	6.2	7.2	860	350	12.0	7.2	160	320	11.0	8.2	81.4
12-24	SCRUBBER DOWN													
12-25	SCRUBBER DOWN													
12-26	NO DATA TAKEN - Crew still on holiday													

[1] Scrubber down to repair leaks
[2] Scrubber start up
[3] Plugged sample line
[4] Scrubber shut down - repair leaks

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-27	0800[1]	142	180.2	6.0	7.0	1000	460	13.8	5.2	160	420	12.0	8.0	84.0
	0900	174	180.2	5.6	7.0	1080	480	13.0	6.4	240	420	12.0	8.0	77.8
	1000	177	NF	5.4	7.1	960	480	14.0	6.0	200	420	11.5	8.4	79.2
	1100	179	NF	5.7	7.1	960	480	14.0	6.0	200	420	11.5	8.5	79.2
	1200	181	NF	6.4	7.1	1040	480	14.0	6.0	180	420	11.3	8.0	82.7
	1300	179	NF	7.4	7.2	1040	460	13.0	7.0	240	420	12.5	8.0	76.9
	1400	177	NF	9.0	7.1	960	460	14.0	6.0	200	380	13.0	6.0	79.2
	1500	175	NF	9.0	7.0	960	460	14.0	6.0	200	380	13.0	6.2	79.2
	1600	175	228.4	8.7	7.0	940	430	12.8	6.4	120	410	11.5	7.8	87.2
	1700	172	228.4	9.3	7.0	920	430	13.4	6.0	130	370	12.8	7.0	85.9
	1800	171	228.4	9.5	7.1	900	435	13.2	6.3	110	380	12.4	7.6	87.8
	1900	172	228.4	9.5	7.0	900	430	13.5	6.3	100	385	12.0	7.5	88.9
	2000	172	228.4	9.5	7.0	900	440	13.3	6.3	110	400	12.1	7.4	87.8
	2100	180	218.1	8.8	7.1	860	440	13.0	6.6	110	400	12.4	7.3	87.2
	2200	179	228.4	9.3	7.1	800	470	14.3	6.2	110	420	12.8	7.4	86.3
	2300	176	228.4	9.3	7.1	870	440	14.2	6.9	80	405	12.9	7.4	90.8
	2400	174	228.4	9.3	7.0	880	450	14.5	5.8	80	410	12.8	7.4	90.9
12-28	0100	175	228.4	9.3	7.0	860	450	14.2	6.2	70	410	13.8	7.0	91.9
	0200	175	228.4	9.3	7.1	820	440	14.2	6.2	70	400	13.6	7.0	91.5
	0300	135	242.2	10.2	7.0	920	450	13.4	6.5	80	420	13.4	6.5	91.3
	0400	135	242.2	10.2	7.0	920	450	14.5	6.2	100	400	14.0	7.0	89.1
	0500	134	242.2	10.2	6.9	920	440	14.2	6.2	80	400	13.4	7.0	91.3
	0600	134	242.2	10.2	6.9	960	440	14.4	6.0	90	400	13.4	7.0	89.5
	0700	158	218.1	9.8	7.0	1100	440	14.3	6.4	100	400	13.8	6.8	90.9
	0800	169	228.4	10.0	7.0	1160	440	14.3	6.2	160	400	13.5	7.0	86.2
	0900	174	228.4	9.6	6.8	1160	440	14.3	6.0	140	410	13.0	7.2	87.9
	1000	170	228.4	10.1	7.0	1120	440	14.0	6.0	120	380	13.3	7.2	89.3
	1100	167	228.4	10.0	7.0	1080	380	14.0	6.1	220	350	13.0	7.0	79.6
	1200	164	228.4	10.1	7.0	1180	350	14.0	6.0	240	320	13.0	7.0	79.7
	1300	164	228.4	10.0	7.1	1020	370	14.0	6.0	120	340	13.0	7.0	89.2
	1400	163	228.4	10.0	7.1	1000	380	14.0	6.0	140	360	13.0	7.1	86.0
	1500	138	228.4	11.0	7.0	1160	370	15.0	5.0	120	360	12.5	7.8	89.7

[1] Crew began taking data

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
12-28	1600[1]	135	242.2	11.0	7.0	1020	390	14.6	6.6	108	360	13.1	7.4	89.4
(contd)	1700	172	228.4	9.6	7.0	1000	380	13.7	6.6	132	350	12.9	7.4	86.8
	1800	172	228.4	9.8	7.0	960	400	14.5	6.0	126	370	13.3	7.4	86.9
	1900	179	228.4	9.6	7.0	960	400	14.6	6.4	120	370	13.4	7.2	87.5
	2000	176	228.4	9.6	7.1	940	400	13.9	6.2	130	380	12.8	7.4	86.2
	2100	179	228.4	9.5	7.1	1000	395	13.9	6.2	138	370	12.5	7.2	86.2
	2200	178	242.2	9.6	7.0	1050	390	14.3	5.9	132	365	13.4	7.0	87.4
	2300	176	242.2	9.6	7.0	1050	385	14.0	6.2	144	355	13.3	7.0	86.3
	2400	134	266.2	10.0	7.0	1020	390	13.8	6.8	144	370	13.3	7.0	85.9
12-29	0100	135	255.0	9.8	6.9	1080	400	13.8	6.7	138	380	13.0	7.5	87.2
	0200	135	255.0	10.0	6.9	1020	400	14.0	6.6	132	360	13.8	6.8	87.1
	0300	135	255.0	10.2	6.9	1020	440	14.8	6.0	126	410	13.5	7.0	87.6
	0400	135	255.0	10.2	6.9	1020	440	14.8	6.0	126	400	14.2	6.8	87.6
	0500	135	255.0	10.2	6.9	1080	440	14.8	6.0	132	400	14.2	6.8	87.8
	0600[2]	135	255.0	10.2	6.9	1080	420	14.8	6.0	138	400	13.8	7.0	87.2
	0700	135	255.0	10.2	7.0	1080	380	15.0	5.8	132	380	14.0	6.8	87.8
	0800	114	266.2	11.0	7.0	1020	370	14.0	7.0	128	340	12.5	8.0	87.6
	0900	102	266.2	10.4	7.0	920	360	13.0	7.2	164	330	11.5	8.5	82.2
	1000	101	228.4	3.3	7.3	1200	360	12.5	8.0	144	320	12.0	8.5	89.0
	1100	101	153.6	3.3	7.2	1360	340	12.5	7.2	240	290	11.0	9.0	82.4
	1200	127	146.4	3.6	7.0	1340	350	14.0	6.5	300	310	11.0	9.0	77.6
	1300	156	159.7	3.0	6.9	1240	380	13.0	6.8	280	310	11.0	8.8	77.4
	1400	157	146.4	2.8	7.0	1520	380	13.0	6.2	320	320	11.5	8.4	78.9
	1500	145	159.7	2.6	6.9	1520	370	13.3	6.0	360	320	12.0	8.0	76.3
	1600	137	165.9	3.5	7.1	1680	370	13.2	5.5	300	330	11.4	7.8	82.1
	1700[3]	148	130.6	0	7.7	200	270	10.2	8.4	1600	380	12.5	6.8	-
	1800	153	130.6	0	*	200	190	7.1	10.0	*	*	*	*	-
12-30	SCRUBBER DOWN													
12-31	SCRUBBER DOWN													

[1] Readings for SO_2 after 1600 are from DuPont unit
[2] Boiler cut to three coal feeders, 0600-1300
[3] Scrubber down at 1645, leak in elbow

HOURLY DATA

Date 1975	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-1	SCRUBBER DOWN													
1-2	SCRUBBER DOWN													
1-3	1545	Scrubber operating with 1st stage only												
	2100[1]	171	266.2	0	OFF	960	440	14.2	5.8	960	440	14.8	5.8	0
	2200[2]	171	266.2	0	OFF	840	420	14.8	5.8	835	420	14.8	5.8	.6
1-4	SCRUBBER DOWN - 1st Stage off line at 0835													
1-5	SCRUBBER DOWN													
1-6	SCRUBBER DOWN													
1-7	1735	1st Stage only												
	2000	183	255.0	3.3	OFF	NF[3]	420	12.6	7.2	NF	390	12.8	7.2	-
	2100	179	266.2	3.5	OFF	NF	375	13.0	6.5	NF	320	13.2	8.6	-
	2200	178	279.6	3.5	OFF	NF	350	12.7	7.2	NF	340	13.1	8.0	-
	2300	182	266.2	3.4	OFF	1080	370	12.5	7.0	1000	380	12.8	7.0	7.4
	2400	180	266.2	3.4	OFF	1120	720	13.5	6.8	NF	670	NF	NF	-
1-8	0100-0200	*[4]	266.2 *	*	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0300	183	266.2	0	OFF	1080	680	13.0	6.8	NF[5]	NF	NF	NF	-
	0400	181	266.2	0	OFF	1120	620	13.0	7.0	960	600	12.0	8.0	14.3
	0500	180	266.2	0	OFF	1120	620	14.0	6.4	1080	600	13.0	7.4	3.6
	0600	177	266.2	0	OFF	1120	620	13.5	6.8	1080	600	13.0	7.4	3.6
	0700	175	266.2	0	OFF	1160	620	14.0	6.2	1080	590	14.0	6.1	6.9
	0800	178	266.2	0	OFF	1280	540	12.5	7.2	1120	520	12.5	7.4	12.5
	0900	182	266.2	0	OFF	1280	430	13.8	6.5	1160	420	13.8	6.8	9.4
	1000	178	266.2	0	OFF	1240	410	13.5	5.8	1140	400	13.5	6.2	8.1
	1100	176	266.2	0	OFF	1240	410	13.5	5.8	1200	370	14.2	6.4	3.2
	1200	181	266.2	0	OFF	1350	400	13.8	5.9	1200	390	14.0	6.2	11.1
	1300	180	266.2	0	OFF	1350	370	14.5	5.9	1210	360	14.0	6.1	10.4
	1400	181	120.3	0	OFF	1480	390	14.0	6.2	1290	380	13.6	6.2	6.5

[1] Trailer on line
[2] Trailer off line due to pump failure
[3] Trailer on line; SO_2 TECO unit down
[4] Sample line repair
[5] First Stage only operating

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-8 (contd)	1405-1600	First Stage down for repairs												
	1700[1]	176	180.2	0	OFF	1300	380	14.2	6.4	1220	370	12.4	6.5	6.2
	1800	179	255.0	0	OFF	1320	375	12.6	5.8	1290	375	12.3	6.2	2.3
	1900	179	291.8	0	OFF	1300	380	12.7	5.8	1290	350	14.0	5.6	2.3
	2000	181	291.8	0	OFF	1380	355	13.4	5.8	1340	350	12.4	6.0	2.9
	2100	180	291.8	0	OFF	1390	350	14.1	5.4	1260	340	12.5	5.9	9.4
	2200	183	291.8	0	OFF	1390	345	13.5	5.5	1280	335	13.2	6.0	7.9
	2300	*	291.8	0	OFF	1430	330	13.6	5.3	1340	320	13.0	5.8	6.3
	2400	*	438.3	0	OFF	1430	330	13.5	5.5	1340	320	13.0	6.0	6.3
1-9	0100[2]	184	291.8	0	OFF	1300	300	13.0	5.2	1300	300	13.0	5.8	0.0
	0200	183	291.8	0	OFF	1400	300	13.0	5.2	1380	280	12.8	6.1	1.4
	0300	184	266.2	0	OFF	1390	300	13.2	5.4	1360	280	13.0	6.0	2.2
	0400	184	291.8	0	OFF	1390	280	13.0	5.4	1360	280	12.8	6.0	2.2
	0500	178	291.8	0	OFF	1500	280	12.2	5.6	1380	280	12.0	6.0	8.0
	0600	179	291.8	0	OFF	1360	280	13.5	5.4	1300	260	13.5	6.0	4.4
	0700	179	291.8	0	OFF	1300	240	13.8	5.4	1300	240	13.5	6.0	0.0
	0800	179	291.8	0	OFF	1300	245	13.8	5.4	1200	220	12.5	6.0	7.7
	0900	170	291.8	0	OFF	1070	420	13.8	5.6	990	410	13.8	6.1	7.5
	1000	154	291.8	0	OFF	1080	420	13.8	5.8	950	410	13.5	5.8	12.0
	1100	154	291.8	0	OFF	1080	420	13.8	5.8	900	410	13.2	5.8	16.7
	1200	149	291.8	0	OFF	1050	450	13.0	5.5	900	440	13.0	5.8	14.3
	1300	149	291.8	0	OFF	980	440	13.5	5.4	900	420	13.2	5.4	8.2
	1400	149	291.8	0	OFF	900	440	13.2	5.6	850	420	13.2	5.8	5.6
	1500	149	291.8	0	OFF	900	460	13.4	5.8	800	440	13.4	5.8	11.1
	1600	147	291.8	0	OFF	780	460	13.3	5.7	720	440	12.8	5.8	7.7
	1700	140	266.2	0	OFF	750	520	12.1	6.5	620	400	12.8	5.6	17.3
	1800	130	291.8	0	OFF	790	470	11.8	7.0	710	470	12.3	6.5	10.1
	1900	133	291.8	0	OFF	710	450	12.2	6.5	680	440	12.3	6.2	4.2
	2000	128	291.8	0	OFF	710	500	12.2	6.0	630	500	11.4	7.4	11.3
	2100	125	291.8	0	OFF	840	400	13.8	5.3	730	455	11.8	6.8	13.1
	2200	126	266.2	0	OFF	820	460	13.3	5.6	730	420	12.0	6.7	8.2
	2300	129	266.2	0	OFF	800	440	12.5	5.9	740	430	12.4	6.4	7.5
	2400	124	266.2	0	OFF	810	480	13.0	6.0	730	460	12.0	7.0	9.9

[1] First Stage only on line
[2] First Stage only operating

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-10	0100	120	266.2	0	OFF	810	390	13.8	6.0	760	450	13.4	6.8	6.2
	0200	119	266.2	0	OFF	800	460	13.4	6.4	770	440	12.8	7.0	3.8
	0300	119	266.2	0	OFF	800	460	13.0	6.6	720	440	13.0	6.8	10.0
	0400	119	266.2	0	OFF	800	460	13.0	6.6	720	440	12.8	7.0	10.0
	0500	119	242.2	0	OFF	800	440	13.4	6.4	720	470	12.8	6.8	10.0
	0600	119	242.2	0	OFF	800	440	13.4	6.4	720	420	13.0	6.8	10.0
	0700	119	266.2	0	OFF	800	440	13.4	6.2	720	420	13.4	6.8	10.0
	0800	119	266.2	0	OFF	900	440	13.8	6.0	800	440	13.5	6.8	11.1
	0830		Complete scrubber shut down											
1-11	1340		Complete scrubber start up											
	1400	174	146.4	1.5	7.8	1100	410	12.5	6.8	340	380	13.4	6.8	69.1
	1500	178	180.2	2.5	7.9	1100	430	14.4	5.8	240	390	12.8	7.8	78.2
	1600	177	197.6	5.0	7.4	NF	450	14.2	5.0	NF	450	11.4	6.8	-
	1700	169	197.6	4.0	6.9	1000	450	13.0	6.2	140	440	13.0	6.8	86.0
	1800	179	197.6	5.5	7.0	1000	450	13.0	6.2	140	440	13.0	6.8	86.0
	1900	177	140.8	3.2	7.2	990	440	13.0	7.0	180	400	11.5	8.0	81.8
	2000	176	197.6	6.0	7.2	1000	440	14.0	6.2	170	400	13.5	6.8	83.0
	2100	176	197.6	6.6	7.1	1000	420	14.2	6.4	120	380	13.0	7.2	88.0
	2200	177	197.6	6.0	7.0	1000	440	14.2	6.4	120	380	13.5	7.2	88.0
	2300	175	218.1	6.0	6.9	1000	440	14.3	6.4	120	380	13.0	7.8	88.0
	2400	135	218.1	7.2	7.1	1140	440	13.5	6.0	140	380	13.0	7.8	87.7
1-12	0100[1]	125	218.1	7.2	7.0	1100	450	14.0	6.0	140	410	12.5	7.2	87.3
	0200	125	242.2	7.4	6.9	1100	440	14.0	6.2	140	410	12.6	7.0	87.3
	0300	126	242.2	7.4	7.0	1200	450	14.0	6.0	160	420	12.5	7.2	86.7
	0400	126	218.1	7.4	7.1	1140	450	13.6	6.4	135	410	13.0	7.4	88.2
	0500	127	218.1	7.4	7.0	1140	440	13.0	6.5	130	410	12.5	7.2	88.6
	0600	114	218.1	6.3	7.2	1100	410	13.5	6.6	145	380	12.0	7.8	86.8
	0700	108	207.4	6.3	7.1	900	400	13.5	6.4	130	385	12.4	7.8	85.6
	0800	109	207.4	5.8	7.1	1080	420	14.2	6.4	150	380	12.4	7.5	86.1
	0900	109	207.4	6.4	6.9	1080	420	13.5	6.4	280	390	13.2	7.5	74.1
	1000	119	197.6	6.2	7.0	1420	430	14.0	5.8	230	380	13.1	7.2	83.8

[1] Coal feeder problems

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-12	1100	127	197.6	6.5	7.0	1580	420	13.5	6.3	270	390	12.8	7.0	82.9
(contd)	1200	127	197.6	6.1	7.0	1580	425	14.6	5.9	260	390	13.1	7.0	83.5
	1300	129	197.6	6.0	7.0	1600	420	14.0	5.8	260	380	13.2	7.2	83.8
	1400	131	188.4	6.0	7.1	1640	425	14.6	5.6	260	380	13.5	6.8	84.1
	1500	132	188.4	6.0	7.1	1640	400	13.4	6.0	270	370	12.8	7.2	83.5
	1600	131	197.6	6.0	7.1	1600	410	14.5	5.8	280	370	13.5	7.0	82.5
	1700	133	197.6	6.0	7.1	1500	400	14.5	6.0	226	370	12.5	7.2	84.9
	1800	133	197.6	6.0	7.1	1400	400	14.5	6.0	250	370	12.5	7.2	82.1
	1900	133	197.6	6.0	7.2	1400	400	14.5	6.0	250	380	12.5	7.0	82.1
	2000	133	218.1	6.0	7.2	1500	400	14.5	5.8	270	380	12.5	7.0	82.0
	2100	133	207.4	6.0	7.2	1450	400	14.5	5.8	270	380	13.0	7.0	81.4
	2200	133	207.4	6.0	7.1	1400	395	14.5	5.8	250	340	12.5	7.0	82.1
	2300	132	218.1	6.0	7.1	1380	380	14.5	5.8	250	340	12.5	7.0	81.9
	2400	125	207.4	6.0	7.1	1380	380	14.0	6.2	250	340	12.0	7.2	81.9
1-13	0100	118	207.4	6.2	6.9	1400	390	12.5	6.5	250	340	11.5	7.6	82.1
	0200	120	197.6	6.2	7.1	1350	390	13.0	6.3	250	340	11.5	7.6	81.5
	0300	119	207.4	6.2	7.1	1300	380	13.5	6.2	230	350	12.0	7.3	82.3
	0400	119	207.4	6.2	7.1	1300	380	13.5	6.2	240	370	12.5	7.2	81.5
	0500	119	207.4	6.2	7.1	1300	380	13.0	6.2	230	340	11.8	7.3	82.3
	0600	120	207.4	6.4	7.1	1300	380	13.5	6.0	230	330	12.5	7.0	82.3
	0700	124	207.4	6.0	7.1	1400	380	13.7	5.8	240	340	12.5	6.8	82.9
	0800	127	207.4	6.2	7.2	1300	380	14.4	5.6	245	340	13.0	6.8	81.2
	0900	130	207.4	5.8	7.2	1150	370	14.3	5.6	235	340	12.5	7.0	79.6
	1000	128	207.4	6.1	7.3	1100	380	14.1	5.6	210	330	12.5	6.8	80.9
	1100	128	207.4	6.3	7.2	1050	385	13.2	5.5	200	340	12.3	6.7	81.0
	1200	129	207.4	6.2	7.1	1000	380	13.7	5.6	205	340	12.2	7.0	79.5
	1300	129	197.6	6.2	7.2	1000	380	14.3	5.5	175	340	12.5	6.8	82.5
	1400	128	197.6	6.5	7.2	1000	380	14.1	5.5	150	340	13.0	7.1	85.0
	1500	129	197.6	6.5	7.1	1000	390	13.8	5.8	140	340	12.8	7.2	86.0
	1600	128	207.4	6.6	7.1	1000	380	14.3	5.5	160	340	12.8	7.1	84.0
	1700	129	207.4	6.4	7.0	1000	390	14.5	5.5	170	350	13.0	7.0	83.0
	1800	129	207.4	6.6	7.0	1000	390	14.0	5.7	130	340	12.7	7.2	87.0
	1900	130	207.4	6.6	7.0	1000	380	14.5	5.5	175	350	13.0	7.0	82.5
	2000	128	207.4	6.6	7.0	1000	420	14.5	5.5	150	370	13.2	7.0	85.0

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	SCRUBBER SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-13	2100	128	207.4	6.8	7.0	1000	400	14.5	5.5	130	360	13.0	7.1	87.0
(Contd)	2200	129	207.4	7.0	7.0	1000	420	14.0	6.0	170	360	12.0	7.6	83.0
	2300	129	207.4	7.0	7.0	1000	400	14.0	6.0	180	340	12.0	7.6	82.0
	2400	129	207.4	6.8	7.0	1050	390	13.9	6.0	350	350	12.2	7.4	66.7
1-14	0100	130	207.4	6.8	7.0	1000	380	13.7	6.0	200	350	12.0	7.2	80.0
	0200	130	207.4	6.8	6.9	1000	380	13.9	5.8	180	340	13.7	7.2	82.0
	0300	130	207.4	6.8	6.8	1000	380	13.7	6.0	160	340	12.5	7.5	84.0
	0400	130	207.4	6.8	7.1	1020	380	13.7	6.0	160	340	12.7	7.3	84.3
	0500	129	207.4	6.8	7.2	1050	370	13.9	6.0	150	340	12.7	7.4	85.7
	0600	129	207.4	6.8	7.1	1050	380	13.8	6.0	150	340	12.7	7.4	85.7
	0700	126	207.4	6.8	7.1	1000	380	13.8	6.2	150	340	12.5	7.4	85.0
	0800	129	218.1	6.8	7.0	1050	360	14.3	NF	160	330	12.3	7.4	84.8
	0900	129	218.1	6.8	6.9	NF[1]	NF	NF	NF	225	310	12.5	7.4	-
	1000	129	218.1	6.7	7.1	1300	360	13.7	6.2	255	310	12.2	7.2	80.4
	1100	127	218.1	6.5	7.3	1280	350	13.6	6.1	260	320	12.4	7.2	79.7
	1200	128	218.1	6.6	7.2	1260	360	13.7	6.0	230	320	12.4	7.2	81.7
	1300	129	218.1	6.6	6.9	1270	360	14.5	6.0	250	330	12.7	7.5	80.3
	1400	128	153.6	2.0	7.0	1250	350	13.0	6.5	270	290	10.1	8.9	78.4
	1500	127	218.1	6.8	7.3	1280	360	13.9	5.9	220	330	12.3	7.5	82.8
	1600	128	228.4	7.0	7.2	1280	360	13.9	6.3	NF	NF	NF	NF	-
	1640		SCRUBBER DOWN - out of MgO											
1-15			SCRUBBER DOWN											
1-16			SCRUBBER DOWN											
1-17			SCRUBBER DOWN											
1-18	1330		SCRUBBER On-Line											
	1400	126	197.5	5.6	7.5	800	420	13.3	6.0	140	390	12.6	6.7	82.5
	1500	150	188.4	4.2	7.2	940	450	12.5	6.8	160	425	12.3	6.7	83.0
	1600	178	188.4	5.4	7.3	900	460	13.0	6.5	140	390	11.0	8.4	84.4
	1700[2]	*	*	*	*	*	*	*	*	*	*	*	*	-

[1] Sample line frozen
[2] Scrubber shut down 1730, I.D. fan down

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-19	1130	SCRUBBER On-Line												
	1200	177	180.2	3.4	7.5	1040	470	13.0	6.4	200	450	12.5	7.0	80.8
	1300	175	173.1	4.4	7.2	1020	450	12.5	6.8	210	420	12.0	7.0	79.4
	1400	*[1]	NF	0	*	1000	440	12.5	7.0	*	*	*	*	-
1-20		SCRUBBER DOWN												
1-21		SCRUBBER DOWN												
1-22		SCRUBBER DOWN												
1-23	1445	SCRUBBER On-Line												
	1500	181	78.8	1.8	7.7	1180	450	13.1	6.6	110	370	10.8	8.6	90.7
	1600	178	74.8	2.0	7.6	1120	440	12.5	7.2	300	420	12.0	8.0	73.2
	1700	176	120.3	3.2	6.9	1200	460	13.0	6.4	280	440	11.8	7.4	76.7
	1800	178	87.0	2.0	7.1	1150	440	13.5	5.6	320	400	11.8	7.4	72.2
	1900	178	87.0	2.0	7.0	1150	440	13.5	6.5	300	400	13.0	7.2	73.9
	2000	178	110.1	1.2	6.9	1200	430	14.0	6.2	290	380	13.0	8.0	75.8
	2100	181	46.1	1.2	7.1	1100	400	13.0	7.1	290	380	12.5	8.0	73.6
	2200	177	87.0	2.4	7.2	1200	440	13.8	6.4	270	340	11.5	9.0	77.5
	2300	173	99.3	3.4	7.3	1180	420	13.0	6.6	250	360	11.5	8.0	78.8
	2400	172	99.3	4.5	7.2	1180	420	13.5	6.2	290	380	11.5	8.0	75.4
1-24	0100	179	120.3	3.6	7.2	1200	440	13.5	6.4	240	380	11.5	8.4	80.0
	0200	176	153.6	4.0	7.2	1200	440	13.5	6.2	240	380	11.5	8.2	80.0
	0300	176	153.6	3.8	7.1	1200	440	13.5	6.4	240	380	11.5	8.4	80.0
	0400	168	140.8	3.8	7.0	1250	440	13.5	6.4	200	390	12.5	7.8	84.0
	0500	168	140.8	3.8	7.0	1300	400	14.5	4.8	240	380	12.0	8.0	81.5
	0600	168	140.8	3.8	7.0	1300	420	13.5	6.4	250	360	12.5	8.2	80.8
	0700	170	120.3	3.8	7.1	1150	400	13.5	5.4	270	340	12.0	8.4	76.5
	0800	175	146.4	4.4	7.1	1100	420	13.3	6.4	200	370	12.2	7.8	81.8
	0900	176	188.4	5.7	7.3	870	420	14.1	6.2	120	360	12.9	7.8	86.2
	1000	174	207.4	7.5	7.4	1050	450	14.4	6.8	120	4.0	12.5	8.2	88.6
	1100	178	207.4	8.0	7.3	1020	450	14.3	6.8	115	410	13.2	8.2	88.7
	1200	175	218.1	8.5	7.3	1080	450	14.2	6.5	120	420	13.6	7.8	88.9
	1300	176	146.4	0	7.5	1070	440	13.7	7.0	255	260	9.1	10.0	76.2

[1] Scrubber down at 1400, 1st stage overflow

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-24	1400	172	135.7	1.0	7.3	1060	415	13.5	6.8	300	370	12.3	8.8	71.7
(Contd)	1500	175	197.6	4.5	7.2	1050	440	13.8	6.7	310	420	13.7	7.2	70.5
	1600	176	242.2	3.4	7.5	1050	440	14.5	6.5	310	420	13.5	7.0	70.5
	1700	176	255.0	3.2	7.2	1000	420	16.0	6.0	680	410	15.5	8.0	32.0
	1800	182	266.2	3.0	8.3	970	420	13.5	7.0	700	420	13.5	7.0	27.8
	1900	176	279.6	3.4	7.8	980	430	14.5	6.4	680	420	14.0	7.0	30.6
	2000	183	266.2	3.0	7.8	940	420	14.5	7.0	690	410	14.0	7.0	26.6
	2100	178	207.4	8.0	7.3	920	420	14.0	6.6	130	360	11.5	8.5	85.9
	2200	178	218.1	8.0	6.9	920	420	13.0	6.8	130	360	12.0	8.0	85.9
	2300	174	218.1	8.0	7.1	950	430	13.5	6.4	140	360	11.5	8.2	85.3
	2400	174	218.1	7.5	7.1	950	410	12.5	6.6	120	360	11.5	8.0	87.4
1-25	0100	175	218.1	7.6	7.1	900	410	12.2	6.4	120	360	11.5	8.0	86.7
	0200	178	228.4	9.0	7.2	900	410	12.0	7.0	120	360	11.2	8.0	86.7
	0300	179	228.4	9.0	7.1	900	400	13.5	6.4	100	360	12.0	8.0	88.9
	0400	172	242.2	9.5	7.0	900	400	13.5	6.6	100	360	12.0	7.8	88.9
	0500	141	228.4	9.5	7.1	900	410	11.5	6.4	100	380	14.0	6.8	88.9
	0600	140	255.0	9.5	7.1	900	440	14.0	6.4	110	410	13.0	7.8	87.8
	0700	138	255.0	9.5	7.1	1000	440	13.5	6.4	140	400	12.5	8.0	86.0
	0800	158	218.1	6.5	7.2	980	420	12.7	6.9	130	370	11.3	7.6	86.7
	0900	177	228.4	8.8	7.2	1050	430	15.6	6.2	120	380	11.2	8.1	88.6
	1000	176	NF	9.0	7.1	1000	420	13.5	6.1	115	380	11.7	7.2	88.5
	1100	175	218.1	9.0	7.0	1000	420	13.5	6.2	120	370	11.5	7.6	88.0
	1200	177	197.6	8.8	7.1	1000	400	13.7	6.3	120	360	12.6	7.8	88.0
	1300	175	188.4	8.8	7.1	1010	400	14.5	6.4	120	370	12.5	7.7	88.1
	1400	177	197.6	8.8	7.1	1020	410	13.0	6.2	120	370	11.9	7.6	88.2
	1500-2400		SCRUBBER DOWN - Leaks in 1st stage											
1-26			SCRUBBER DOWN											
1-27	0100-0500		SCRUBBER DOWN											
	0600[1]	116	NF	.7	7.4	1000	400	13.8	7.0	280	310	12.5	8.0	72.0
	0700	163	NF	1.8	7.4	1000	440	12.0	7.2	280	380	11.5	8.6	72.0

[1] Start up 0525

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
1-27	0800	176	NF	0.2	7.5	900	410	13.6	7.6	240	380	11.1	8.5	73.3
(contd)	0900[1]	162	309.2	13.0	7.5	900	410	13.5	7.5	63	400	12.2	8.6	93.0
	1000	116	255.0	10.8	7.4	910	400	13.5	6.9	80	390	12.9	7.8	91.2
	1100	138	242.2	10.2	7.2	940	460	14.1	6.2	105	460	13.3	6.7	88.8
	1200	174	207.4	8.0	7.2	1020	510	13.3	7.0	130	450	12.0	8.5	87.3
	1300	175	207.4	7.8	7.3	1020	520	13.2	8.5	125	450	11.8	8.5	87.7
	1400	174	228.4	8.0	7.1	1020	520	13.3	6.7	125	450	11.5	6.7	87.7
	1500[2]	173	188.4	2.2	7.2	1010	480	14.5	7.0	160	420	12.7	7.0	84.2
	1600-2400		SCRUBBER DOWN											
1-28			SCRUBBER DOWN - Test crew packed up equipment											
1-29			SCRUBBER DOWN - Test crew left site											
1-30 to 8/10			Boiler and Scrubber down for maintenance and repairs											
8-11	0100-1300													
	1435[3]	185	87.0	1.7	*3	10	NF	.5	*	590	NF	11.5	*	-
	1500[4]	185	180.2	1.8	*	660	NF	12.6	*	130	NF	12.4	*	80.3
	1600	182	180.2	2.7	*	700	NF	12.5	6.0	130	NF	12.2	6.8	81.4
	1700	185	207.4	3.0	*	700	NF	12.3	6.2	130	NF	10.0	8.8	81.4
	1800	182	218.1	2.6	7.7	670	NF	12.5	6.2	110	NF	10.5	8.6	83.6
	1900	182	218.1	3.3	*	680	NF	12.5	6.1	110	NF	10.5	8.4	83.8
	2000	183	218.1	3.4	7.3	680	NF	12.5	6.0	100	NF	10.5	8.5	85.3
	2100	184	218.1	3.3	*	680	NF	12.5	6.0	110	NF	10.5	8.6	83.8
	2200	183	218.1	3.4	7.1	700	NF	13.0	6.0	110	NF	10.5	8.5	84.3
	2300	183	218.1	3.2	*	640	NF	13.0	6.1	100	NF	10.5	8.6	84.4
	2400	183	218.1	3.2	7.0	600	NF	13.0	6.0	100	NF	10.5	8.7	83.3
8-12	0100	184	218.1	3.2	*	600	NF	12.5	6.0	90	NF	10.5	8.8	85.0

[1] High Gas Flow 0815
[2] Scrubber down 1540
[3] Trailer readings suspect until 1000, 8/12
[4] Scrubber start up

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8-12	0200	162	242.2	3.7	7.0	600	NF	12.5	5.9	90	NF	10.5	8.6	85.0
(Contd)	0300	141	242.2	3.7	*	590	NF	13.0	6.0	90	NF	10.5	8.6	84.7
	0400	151	218.1	3.7	7.0	550	NF	13.0	5.6	90	NF	11.0	8.3	83.6
	0500	177	228.4	3.3	*	600	NF	NF	5.8	80	NF	NF	8.4	86.7
	0600	150	242.2	3.3	7.0	600	NF	NF	5.8	90	NF	NF	8.3	85.0
	0700[1]	150	228.4	3.3	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0800[2]	183	188.4	4.0	6.8	780	NF	NF	NF	294	NF	NF	NF	62.3
	0900	184	197.6	2.9	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1000	186	197.6	2.5	6.8	1020	NF	NF	NF	300	NF	NF	NF	70.6
	1100	187	197.6	2.9	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1200	185	197.6	3.0	7.1	1080	NF	NF	NF	300	NF	NF	NF	72.2
	1300	185	197.6	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1400	185	197.6	3.0	7.0	1080	NF	NF	NF	300	NF	NF	NF	72.2
	1500	184	197.6	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1600	185	188.4	3.0	7.1	1140	NF	NF	NF	300	NF	NF	NF	73.7
	1700	184	197.6	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1800	184	197.6	3.0	7.1	1140	NF	NF	NF	300	NF	NF	NF	73.7
	1900	183	197.6	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2000	185	197.6	3.0	7.1	1140	NF	NF	NF	300	NF	NF	NF	73.7
	2100	183	197.6	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2200	184	207.4	3.0	6.8	1140	NF	NF	NF	300	NF	NF	NF	73.7
	2300	181	207.4	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2400	184	207.4	3.2	7.0	1140	NF	NF	NF	300	NF	NF	NF	73.7
8/13	0100	179	197.6	2.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0200	185	197.6	2.8	7.0	1140	NF	NF	NF	262	NF	NF	NF	77.0
	0300	181	197.6	2.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0400	180	218.1	3.5	7.0	1200	NF	NF	NF	300	NF	NF	NF	75.0
	0500	155	210.1	3.6	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0600	164	207.4	3.2	7.1	1200	NF	NF	NF	300	NF	NF	NF	75.0
	0700	186	207.4	3.2	*	NF	NF	NF	NF	NF	NF	NF	NF	-

[1] Gas conditioner problems
[2] DuPont SO_2 readings
[3] DuPont SO_2 readings

HOURLY DATA

Date	Time	MW	Inlet ΔCFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8/13	0800	184	218.1	3.3	7.0	1140	NF	NF	NF	294	NF	NF	NF	74.2
(Contd)	0900	184	218.1	3.3	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1000	182	218.1	3.3	7.0	1140	NF	NF	NF	294	NF	NF	NF	74.2
	1100	183	218.1	3.6	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1200	180	218.1	3.6	7.1	1080	NF	NF	NF	240	NF	NF	NF	77.8
	1300	183	218.1	3.6	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1400	182	207.4	3.6	7.0	1170	NF	NF	NF	270	NF	NF	NF	76.9
	1500	181	207.4	3.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1600	183	207.4	3.8	7.1	1200	NF	NF	NF	300	NF	NF	NF	75.0
	1700	184	207.4	3.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1800	185	218.1	3.8	7.1	1260	NF	NF	NF	300	NF	NF	NF	76.2
	1900	184	218.1	3.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2000	187	207.4	3.8	7.1	1260	NF	NF	NF	300	NF	NF	NF	76.2
	2100	184	207.4	3.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2200	184	207.4	3.8	6.9	1260	NF	NF	NF	300	NF	NF	NF	76.2
	2300	184	207.4	3.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2400	188	120.3	2.8	7.1	1260	NF	NF	NF	360	NF	NF	NF	71.4
8/14	0100[1]	183	120.3	1.4	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0200	186	135.7	1.4	7.2	1260	NF	NF	NF	360	NF	NF	NF	71.4
	0300	170	66.6	2.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0400	150	66.6	0.4	7.4	1080	NF	NF	NF	180	NF	NF	NF	83.3
	0500	151	66.6	0.4	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0600	150	66.6	0.4	7.3	1080	NF	NF	NF	180	NF	NF	NF	83.8
	0700	178	66.6	0.3	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0800	183	82.9	0.8	7.1	1080	NF	NF	NF	240	NF	NF	NF	77.8
	0900	186	87.0	0.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1000	184	82.9	0.8	7.1	1080	NF	NF	NF	240	NF	NF	NF	77.8
	1100	181	82.9	0.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1200	181	82.9	0.8	7.1	1020	NF	NF	NF	240	NF	NF	NF	76.5
	1300	178	82.9	0.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1400	178	82.9	0.8	7.1	1020	NF	NF	NF	240	NF	NF	NF	76.5

[1] DuPont SO_2 readings

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8-14	1500	179	82.9	0.8	*	NF	NF	NF	NF	NF	NF	NF	NF	-
(Contd)	1600	179	82.9	0.8	7.1	960	NF	NF	NF	240	NF	NF	NF	75.0
	1700	177	105.0	1.3	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1800	177	110.1	1.3	7.0	960	NF	NF	NF	240	NF	NF	NF	75.0
	1900	178	140.8	2.3	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2000	179	140.8	2.4	6.9	1020	NF	NF	NF	240	NF	NF	NF	76.5
	2100	183	165.9	3.0	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2200	178	165.9	3.0	7.0	1020	NF	NF	NF	240	NF	NF	NF	76.5
	2300	178	180.2	3.5	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	2400	179	180.2	3.5	7.1	1020	NF	NF	NF	240	NF	NF	NF	76.5
8-15	0100[1]	181	188.4	3.6	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0200[2]	178	188.4	3.8	7.2	1080	NF	NF	NF	240	NF	NF	NF	77.8
	0300[3]	178	207.4	4.1	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0400-2400	SCRUBBER DOWN												
8-16		SCRUBBER DOWN												
8-17		SCRUBBER DOWN												
8-18		SCRUBBER DOWN												
8-19		SCRUBBER DOWN												
8-20		SCRUBBER DOWN												
8-21		SCRUBBER DOWN												
8-22	0100-1400	SCRUBBER DOWN												
	1430[4]	176	*	1.5	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1500[5]	175	153.6	2.0	*	1150	NF	13.0	6.0	370	NF	13.0	7.8	67.8
	1600	177	165.9	2.0	7.4	1200	NF	13.5	6.0	350	NF	12.5	7.3	70.8
	1700[6]	179	173.1	2.0	*	1190	NF	14.5	6.1	340	NF	12.7	7.2	71.4

[1] DuPont SO_2 readings
[2] Dryer plugged
[3] Scrubber down 0400 - dryer plugged
[4] Scrubber start up
[5] Trailer on line
[6] Velocity increase 1630

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8-22	1800	184	207.4	3.2	7.3	1150	NF	13.5	5.6	300	NF	12.5	6.6	73.9
(Contd)	1900	180	207.4	3.4	*	1090	NF	13.7	6.2	290	NF	12.0	7.2	73.4
	2000	177	207.4	3.4	7.2	1100	NF	12.5	6.2	300	NF	12.3	7.2	72.7
	2100	181	207.4	3.4	*	1095	NF	13.0	6.2	300	NF	12.0	7.3	72.6
	2200	178	197.6	3.4	7.2	1100	NF	12.5	6.5	295	NF	11.9	7.4	73.2
	2300	176	197.6	3.4	*	1000	NF	13.4	6.4	270	NF	12.5	7.4	73.0
	2400	178	197.6	3.4	7.0	1000	NF	13.4	6.4	280	NF	12.6	7.2	72.0
8-23	0100	184	197.6	3.4	*	1100	NF	13.3	6.5	290	NF	12.6	7.3	73.6
	0200	181	188.4	4.2	7.0	1040	NF	13.2	6.7	300	NF	12.6	7.6	71.2
	0300	170	218.1	4.2	*	1025	NF	13.3	6.5	270	NF	12.7	7.4	73.7
	0400	138	228.4	4.2	6.9	1090	NF	13.0	6.7	250	NF	12.5	7.5	77.1
	0500	117	228.4	4.2	*	1075	NF	13.1	6.9	250	NF	12.5	7.7	76.7
	0600[1]	116	228.4	4.2	6.9	1020	NF	NF	NF	180	NF	NF	NF	82.4
	0700	115	228.4	4.2	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	0800	116	228.4	4.2	6.9	1140	NF	NF	NF	300	NF	NF	NF	73.7
	0900	125	218.1	4.2	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1000	171	207.4	3.7	7.1	1200	NF	NF	NF	300	NF	NF	NF	75.0
	1100	177	207.4	3.7	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1200	181	207.4	3.7	7.1	1200	NF	NF	NF	300	NF	NF	NF	75.0
	1300	176	197.6	3.7	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1400	180	207.4	3.7	6.9	1380	NF	NF	NF	420	NF	NF	NF	69.6
	1500	174	207.4	3.7	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1600[2]	171	207.4	3.5	6.9	1380	NF	NF	NF	390	NF	12.0	7.4	71.7
	1700	170	207.4	3.2	*	NF	NF	NF	NF	420	NF	12.6	7.0	-
	1800	182	197.4	3.2	7.0	1440	NF	NF	NF	400	NF	12.6	6.8	72.2
	1900	181	207.4	3.2	*	NF	NF	NF	NF	400	NF	12.8	6.8	-
	2000	174	207.4	3.2	7.0	1500	NF	NF	NF	410	NF	12.8	6.6	72.7
	2100[3]	180	207.4	3.2	*	NF	NF	NF	NF	400	NF	12.7	6.7	-
	2200	178	146.4	1.5	7.0	1080	NF	NF	NF	500	NF	12.3	7.8	53.7
	2300	174	146.4	1.0	*	NF	NF	NF	NF	470	NF	12.4	7.0	-
	2400	158	120.3	1.0	*	NF	NF	NF	NF	500	NF	12.3	7.6	-

[1] DuPont SO_2 readings, conditioners malfunctioned
[2] Outlet mode of trailer on-line
[3] Centrifuge Clog

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8-24	SCRUBBER DOWN - 0305													
8-25	SCRUBBER DOWN - 0100-1300													
	1330	184		0.0										
	1400[1]	175	173.1	1.8	7.3	1080	NF	NF	NF	360	NF	NF	NF	66.7
	1500[2]	178	173.1	3.2	*	NF	NF	NF	NF	NF	NF	NF	NF	-
	1600	182	180.2	3.2	7.3	1140	NF	NF	NF	310	NF	13.0	6.7	72.8
	1700	180	180.2	3.2	*	NF	NF	NF	NF	320	NF	12.9	7.4	-
	1800	176	180.2	3.2	7.3	1140	NF	NF	NF	340	NF	11.5	7.4	70.2
	1900	177	173.1	3.2	*	NF	NF	NF	NF	310	NF	12.5	7.4	-
	2000	175	180.2	3.2	7.3	1140	NF	NF	NF	310	NF	12.5	7.0	72.8
	2100	182	188.4	3.2	*	NF	NF	NF	NF	340	NF	12.7	6.8	-
	2200[3]	173	188.4	3.2	7.0	1250	NF	13.0	5.8	350	NF	12.5	7.0	72.0
	2300	171	188.4	3.2	*	1325	NF	13.7	5.8	375	NF	13.0	6.8	71.7
	2400	180	188.4	3.2	7.0	1325	NF	12.8	5.8	380	NF	11.6	6.9	71.3
8-26	0100	177	188.4	3.2	*	1275	NF	12.6	5.8	380	NF	11.6	6.9	70.2
	0200	179	188.4	3.2	6.9	1200	NF	12.6	5.3	350	NF	11.5	7.1	70.8
	0300	182	188.4	3.2	*	1175	NF	12.5	5.8	360	NF	11.5	7.0	69.4
	0400[4]	176	197.6	3.2	6.9	1300	NF	12.5	6.1	390	NF	12.0	7.0	70.0
	0500	183	197.6	0.7	*	1200	NF	12.5	6.6	400	NF	10.5	9.0	66.7
	0600	180	197.6	3.4	6.9	1300	NF	12.5	5.9	400	NF	11.8	7.1	69.2
	0700	176	125.4	0.8	*	1350	NF	13.0	6.5	400	NF	11.0	7.0	70.4
	0800	177	125.4	0.9	7.2	1300	NF	13.0	6.6	425	NF	12.0	8.6	67.3
	0900	176	120.3	0.9	*	1325	NF	13.5	6.6	480	NF	12.2	8.4	63.8
	1000	178	120.3	0.8	7.1	1300	NF	12.9	6.8	425	NF	11.5	8.7	67.3
	1100	180	146.4	1.6	*	1225	NF	14.0	6.2	400	NF	12.7	8.0	67.3
	1200	184	146.4	1.6	7.1	1200	NF	14.4	6.3	400	NF	13.5	7.2	67.7
	1300	185	173.1	2.8	*	1150	NF	14.6	6.0	300	NF	13.3	7.2	73.9
	1400	185	197.6	3.6	6.8	1050	NF	14.5	5.9	290	NF	14.0	6.7	72.4

[1] DuPont SO_2 inlet readings
[2] Scrubber start up
[3] Trailer On-line
[4] Velocity change

HOURLY DATA

Date	Time	MW	Inlet ACFM x 1000	SCRUBBER 2nd Stage ΔP	SCRUBBER 2nd Stage pH	INLET SO_2 ppm	INLET NO_x ppm	INLET CO_2 %	INLET O_2 %	OUTLET SO_2 ppm	OUTLET NO_x ppm	OUTLET CO_2 %	OUTLET O_2 %	% SO_2 Removal Efficiency
8-26	1500	184	197.6	3.6	*	1100	NF	14.1	5.6	275	NF	12.5	6.7	75.0
(contd)	1600	186	197.6	3.6	7.1	1150	NF	12.5	5.6	300	NF	11.5	6.8	73.9
	1700	183	NF	3.6	*	1200	NF	14.4	5.8	325	NF	13.5	6.5	72.9
	1800[1]	178	NF	3.5	7.1	1125	NF	13.8	6.4	325	NF	13.5	7.1	71.1
	1900	174	173.1	0.8	*	1125	NF	13.7	6.4	1100	NF	13.0	7.0	2.2
	2000	171	173.1	0.9	*	1125	NF	13.4	6.2	1050	NF	12.6	6.8	6.7
	2100	170	188.4	0.9	*	*	NF	*	*	1050	NF	12.5	7.1	-
	2200	170	78.8	0.9	*	*	NF	*	*	1030	NF	13.3	6.9	-
	2300	172	180.2	0.9	*	*	NF	*	*	1025	NF	13.4	6.9	-
	2400	175	188.4	0.9	*	*	NF	*	*	1075	NF	13.5	6.9	-
8-27	0100	178	173.1	0.8	*	NF	NF	NF	NF	1100	NF	13.5	6.9	-
	0200	179	173.1	0.8	*	NF	NF	NF	NF	1100	NF	13.5	6.8	-
	0300	179	173.1	0.8	*	NF	NF	NF	NF	1100	NF	13.5	6.8	-
	0400	179	173.1	0.8	*	NF	NF	NF	NF	1080	NF	13.6	7.0	-
	0500	182	173.1	0.8	*	NF	NF	NF	NF	1190	NF	13.3	7.0	-
	0600	183	173.1	0.8	*	NF	NF	NF	NF	1125	NF	13.3	7.1	-
	0700	182	165.9	0.8	*	NF	NF	NF	NF	1130	NF	13.5	7.0	-
	0800	180	180.2	0.8	*	NF	NF	NF	NF	1150	NF	13.5	6.3	-
	0900	181	180.2	0.8	*	NF	NF	NF	NF	1100	NF	14.0	6.3	-
	1000	180	180.2	0.8	*	NF	NF	NF	NF	800	NF	14.1	6.3	-
	1100	176	180.2	0.8	*	NF	NF	NF	NF	1270	NF	13.1	6.6	-
	1200	178	180.2	0.8	*	1450	NF	13.5	6.1	1250	NF	13.0	7.2	13.8
	1300	179	180.2	0.8	*	NF	NF	NF	NF	1300	NF	13.0	6.6	-
	1400[2]	175	87.0	0.2	*	1400	NF	13.3	6.6	1200	NF	12.5	7.1	14.3
	1500	180	87.0	0.2	*	1300	NF	13.0	6.7	1150	NF	12.5	7.3	11.5
	1530-2400		SCRUBBER completely shut down 1530											
8-28			Test Crew packed up equipment and left											

[1] Second stage shut down 1830
[2] First stage shut down

APPENDIX C

DAILY OPERATING LOGS

NOVEMBER 1974

1974

Nov. 1 - The scrubber was not in operation. The hub for the "B" MgO pump was not available; operators settled for reboring the old hub and reassembled the pump. A new 3HP motor was installed on dryer conveyor. Some attention and effort was placed on reducing the spillage when loading $MgSO_3$.

Nov. 2 - The centrifuge cover was installed as was the vibrator on the $MgSO_3$ silo. Work was completed on the pipe line, and the 14 inch discharge line at the "B" recycle pump (first stage) was finished. Installation of a pump coupling on the "B" MgO slurry pump was accomplished and a truck load of MgO was received.

Nov. 3 - Sunday

Nov. 4 - Welding contractor began repairing various pipes. The man-way on the first stage was opened.

Nov. 5 - Inspected first stage inner cone. One break in the lining in compression ring of inner skirt under the modules was noted but no repairs were initiated. The rod below the hanger was fine as was the plumb bob. The vortex breaker showed signs of erosion or etching. The hangers supporting the first stage cone were acceptable.

Nov. 6 - The first stage man-ways were closed. An outboard bearing on the top of the bucket elevator was worn out. Repairs were made on leaks in the steam line and on the top of the scrubber. All bearings were lubricated and the oil levels checked. The plumb bob was operated as a check.

Nov. 7 - Work was done on cutting out and cleaning the "A" MgO line. A leak was fixed in the sump pump discharge line. The car of MgO was unloaded. Completed work on Suction/ Discharge headers except for "patches" or overlay pieces, which still needed welding.

Nov. 8 - Installed bearing on top of the bucket elevator. Work on the MgO pumps and lines has been completed; pump performance will be tested. The first stage was filled and leak tested.

Nov. 9 - The centrifuge was started for pre-run time. The MgO storage tank was heated. The thickeners were refilled. The weigh belts were recalibrated and zeroed. All solids handling equipment was test run. Water was introduced into the second stage. At 1600 hours the "B" MgO pump stopped. An electrician was called to install a larger heater in the switch. By 2000 hours

the pump was back in service. The "A" MgO line was well flushed with hot water. The level of MgO was lowered to 20% and the first batch was prepared at 2100 hours. The man-ways on the gas ducts were closed.

Nov. 10 - At 0140 hours the fan was started but it tripped out because the damper did not open. At 0145 the fan was started again and gas went through the scrubber. At 0300 hours the flow was raised to 148,000 ACFM. The pH was erratic due to the malfunctioning of the meter in the scrubber control room. At 0800 hours the solids handling equipment was put on line. The MgO slurry in the tank turned to putty at 0930, and the load was reduced to 94,000 ACFM. A new batch of MgO was made and at 1245 hours the load was brought to 118,000 ACFM. Since the pH was not held constant during this period of operation, many changes in flow were experienced. At 1645 the steam control valve on the MgO tank failed to control the temperature, the steam to the tank was then put on manual control. At 2300 hours, a hole was discovered in the mother liquor return line on the second stage of the scrubber.

The continuous monitoring trailer experienced some problems after start up. Probe filters had to be altered as they were restricting flow. Temperatures in the conditioning system had to be changed due to moisture reaching the analyzers. SO_2 readings from 0220 to 0745, O_2 readings from 2045 through midnight and CO_2 readings all day may be incorrect because of these problems.

Nov. 11 - At 0245 hours the stack gas was routed out of the scrubber, so repairs could be made. The following problems were noted at this time: a broken electrode and a leak in the pH meter system, a plugged MgO line to the absorber, and the recycle slurry line from the absorber to the centrifuge was parted at the discharge header. The steam controller on the steam line to the MgO tank was found to be operating properly, but it appeared the check was sticking. A mechanic was not available today from either Pepco or Hurley.

Nov. 12 - The MgO tank was drained and flushed in an attempt to find the restriction in the line to "B" pump. The instrumentation department worked on the temperature monitor and steam control check valves. Changes were made in the continuous monitoring system so the SO_2 unit could automatically change scales for inlet/ outlet modes.

Nov. 13 - Four mechanics from Hurley reported for work in the morning. The thermocouple for temperature monitoring in the circulation line was placed in the vertical

position for more effective readings. Gas was routed into the scrubber at 2010 hours. The pH meter was still not functioning correctly but the steam line to the MgO tank was working properly. The loading was increased to 148,000 ACFM at 2130.

A probe blow-back system for the continuous monitoring trailer was installed and made operative. This should reduce flow problems caused by probe plugging. The sampling site for mother liquor samples was changed in order to take a more representative sample. York Research personnel were asked to take pH readings every 15 minutes as the scrubber plant pH meter was not working properly.

Nov. 14 - The scrubber operated all day. The batch of MgO appears to have had low reactivity. Research is needed to evaluate the quality of the MgO effect on slurry tank temperature and its reaction with mother liquor to determine why the slurry jelled again as it did on Nov. 10th. The centrifuge drop-out hopper plugged up and had to be cleaned out. The "B" thickener dump valve fully opened causing the dilution tank to overflow. Electricians were called to make repairs to the MgO Belt indicator, heat tape, rake lowering mechanism and $MgSO_3$ weigher motor. The steam line valve to the MgO tank was shut off to observe the effect.

The continuous monitoring system was operational but some problems developed with leakage and outlet probe blockage. These were corrected during the day. The SO_2 readings from 0530 to 0830, O_2 until 0830 hours and CO_2 readings may have been incorrect.

York personnel were performing pH tests every half hour in order to check the accuracy of the scrubber plant pH meter.

Nov. 15 - The scrubber was operated all day today. Early in the day the flow had to be reduced to 110,000 ACFM from 160,000 ACFM due to foreign material plugging the weigh feeder belt. The flow was brought back up when the problem was corrected.

The centrifuge cover was removed and the hopper was cleaned out. There was no spout extension for use when loading $MgSO_3$, as was requested on Nov. 1. Therefore, approximately 1.5 tons of $MgSO_3$ were spilled. When stripping the crystals which had accumulated in the absorber while the centrifuge was being repaired, it was found the maximum flow to the centrifuge was 55 gpm. This may be a limiting factor in the amount of gas sent to the absorber. The pH meter had to be repaired and was working properly by 1600 hours. The

north thickener was put into operation as a leak developed in the cone of the south thickener.

Rolland Glenn requested York chemists to take two centrifuge cake samples per day and prepared them for shipping to Rumsford, Rhode Island. (Essex Regenerating Plant)

The CO_2 readings for the entire day are probably incorrect due to an electrical problem within the monitor.

Nov. 16 - York chemists were asked to verify the buffer solution used for the pH meters. Both meters (bench and continuous) were found to be about 0.3 pH units high. The $MgSO_3$ conveyor at the top of the silo tripped and the centrifuge was diverted. The $MgSO_3$ weigh belt broke and was placed on by-pass. The bucket elevators and centrifuge product screw malfunctioned in late afternoon and had to be reset. The bucket elevator kept malfunctioning during the evening and had to be dug out and reset numerous times. At about 1800 hours the flow was reduced due to a low pH and the problems with the bucket elevator. A 6 inch pinch valve to the tangential spray ruptured at 1930 hours. Gas was taken out of scrubber at 2135 hours. The second stage was operated until 0400 Nov. 17 to strip out the solids.

The continuous monitoring trailer was operating until 1000 hours when it was shut down to replace the outlet probe with one of better design. The sample lines also had to be flushed out. Monitoring continued at 1900 hours. The CO_2 readings are probably inaccurate.

Nov. 17 - The scrubber was not in service today. The equipment downstream of the scrubber was washed out. The screw conveyor from the dryer to the bucket elevator was inspected. The gear box needs to be inspected more carefully as it is very noisy. The south thickener finished draining during the day.

Nov. 18 - The scrubber was not in service today. Three Hurley mechanics were in working on a first stage line. It was found the key in the drive sheave of the dryer screw conveyor was loose and worn, and it was repaired. PEPCO operators removed the bolts from the centrifuge cover and the second stage discharge header was found to be drained.

Nov. 19 - The scrubber was not in service at the start of the day. The agitator on "A" dilution tank was hooked up electrically and filled with oil. It was then ready for service. The mechanical seal on "B" pump was leaking badly when it was started. The liner was removed and replaced in the centrifuge divert valve. Eleven bolts

in the "B" thickener were found to be nearly decomposed and were replaced. Gas went to the scrubber at 1740 hours. The centrifuge cover was still leaking.

Continuous monitoring trailer was operating well after the first two hours of operation. A bad solenoid valve caused false readings until approximately 2030 hours. The CO_2 readings are probably inaccurate.

Nov. 20 - The scrubber operated all day. At the start of the day, the flow had to be reduced to remove some debris from the MgO belt. By 0100 hours the load had been increased to 82% of design. The impeller was removed from "A" recycle pump and Chemico personnel requested PEPCO to order a back-up one. The bearing on the inside of Dryer #2 conveyor to the silo had come apart. This was what probably caused the conveyor to trip on Nov. 16. A new leak developed in the centrifuge cover during the day.

The continuous monitoring trailer was semi-operational, with the SO_2 unit output very low and the CO_2 unit down (CO_2 readings were taken by EPA Method 3).

The chemical trailer operation was normal. Some special analyses were performed on the sump discharge, the process water and the second stage bleed. Also some changes were made in analytical procedures due to the detection of interferences in some of the samples.

Nov. 21 - The scrubber operated most of the day. At 0110 hours the bucket elevator tripped. The load reduced by about 45,000 ACFM at 0130 hours to reduce the build-up of crystals. The temperatures associated with the dryer did not appear correct but this may have been due to one of the thermocouples having been located near an air leak from outside the dryer. The front rappers fell off the dryer in the morning, causing the thermocouples to the fire box to be ripped out. The centrifuge hopper had to be washed out and an attempt was made to weld the holes in the centrifuge cover. At 1520 hours the flow was reduced to 187,000 ACFM to reduce crystal formation. At 2000 the belts on the dryer ID fan burned off, and the gas was removed from the scrubber. A mechanic was called out to replace the belts.

The continuous monitoring trailer was semi-operational. The SO_2 and CO_2 units were repaired during the day.

Meetings were held by York, PEPCO and Chemico representatives.

Nov. 22 - The scrubber did not operate today. An electrician was called in at 0030 hours to check the fan. The housing was half filled with water; it was drained,

but it still would not perform at the proper speed. The duct and dryer man-way covers were removed and the #2 screw conveyer was inspected. The mechanics removed the dryer fan pulley for replacement. The centrifuge cover was welded again today. Two trucks each removed a load of $MgSO_3$. An unsuccessful attempt was made at cleaning the second stage overflow line.

Nov. 23 - The scrubber did not operate. The work on the rappers and on the dryer ID fan was completed.

Nov. 24 - The scrubber operated for part of the time. At 0240 hours, gas entered the scrubber. At 0830 hours, the gas was taken out of the scrubber as the sheave bushing in the dryer gear box was the wrong size. The sheave was replaced and the scrubber was started at 1445 hours at 153,600 AFCM. By 1900 hours the flow was up to 218,100 ACFM.

Nov. 25 - The scrubber operated all day. The flow was cut back to 82,900 ACFM. The bucket elevator and screw conveyor had to be cleaned out. By 0400 hours the load had been increased to 91,100 ACFM. At 0945 hours the flow stabilized at 175,000 ACFM.

The continuous monitoring trailer operated well except for some outlet flow problems which were corrected as soon as they occurred.

Nov. 26 - The scrubber operated all day with a flow of 165,000 ACFM. Repair work began on the south thickener valves. During the day the cover and hopper from the centrifuge had to be washed out. A leak developed in a 6 inch water recycle line on the first stage and it was sealed with a rubber lined clamp-on band.

The continuous monitoring trailer had some flow problems. These were attributed to icing in an unheated part of the sampling line. Heating tape was installed to correct the problem.

Nov. 27 - The scrubber operated all day. The level control on the first stage and MgO tank were not working properly and had to be repaired. The maintenance department finished installing the valve on the south thickener. Variations in pH during the day have been attributed to coal feeder problems in the plant, which affect the inlet SO_2 concentrations.

The continuous monitoring trailer was not operational during most of the day because of a pump failure. Several unsuccessful attempts were made to repair the pump. Before the pump failure, an SO_2 comparison test had been made on the duct, trailer and analyzer. The readings differed by 6%.

Nov. 28 - The scrubber operated all day but with some problems. A leak developed in the first stage ball nozzle distribution header and had to be patched. The drain nipple on the bottom of the sump pump discharge line also started to leak. The feed was diverted because the dryer drum had become over-loaded. This was reflected in the very wet consistency of the centrifuge product. The centrifuge case started leaking worse than it had been and the continuous pH meter was not operating properly.

One York chemist was on hand during the day shift during this holiday period.

Nov. 29 - The scrubber operated all day. A leak developed in the line from the first stage to the distribution box. The load was reduced in order to maintain the pH while the boiler output was reduced. Patch clamps were installed in the 6 inch bleed line, recycle line, and on the discharge header of the first stage. The dryer became overloaded again and the centrifuge feed had to be diverted to allow the dryer to clear out. At 1745 hours the load was increased. The south thickener was filled with water and placed on standby.

The sampling pump on the continuous monitoring trailer was replaced during the day and the trailer was made operational.

Nov. 30 - The scrubber operated all day. Some problems were encountered maintaining pH due to boiler fluctuations. The centrifuge hopper had to be washed out during the day. The load was increased to 228,400 ACFM at 1020 hours.

The continuous monitoring trailer was operational but some flow problems developed.

DECEMBER, 1974

Dec. 1 - The scrubber operated most of the day but had many problems. The torus sprays in the southwest corner gave way. At 0800 hours flow was stopped to the torus sprays but the Chemico operator was unable to remove the flange bolts to insert the blind. The flow was restored to the sprays but at a reduced rate. The 6 inch scrubber bleed to thickener line developed another leak but no pipe clamps were available to patch it. The gas was taken from the scrubber at 2200 hours because the first stage level could not be controlled.

The continuous monitoring trailer operated part of the day. The down time was attributed to flow and electrical problems. These were corrected by 0900 hours.

Dec. 2 - The scrubber did not operate today.

Dec. 3 - The scrubber did not operate. Blanks were installed in two lines at the top of the scrubber. While cleaning the pre-mix tank, the laborers dropped a bar into the down-comer and it had to be drained to remove the bar. The 1 inch mother liquor line to the pre-mix tank broke and had to be replaced. A rubber insert was to be used on the 6 inch line to the thickener until a new section of line was ready (approx. Dec. 9). A first stage elbow section of line was removed from the top of the scrubber; a replacement was made and will be ready for rubber lining tomorrow.

York chemists performed special analyses while the continuous monitoring trailer personnel performed maintenance and read data.

Dec. 4 - The scrubber did not operate. The work on the 6 inch bleed line for the first stage was completed. Work was perfomred on the mother liquor to pre-mix tank line and on the pH meter. The second stellited restricting orifice plate was removed from the bleed line to the thickener. An attempt was made to start the centrifuge but it kept tripping off. A broken shear pin on the centrifuge was found.

A new inlet probe was installed for the continuous monitoring trailer.

Dec. 5 - The scrubber was operated during the later part of the day. The centrifuge had to be flushed with steam and water before it was freed. The mother liquor to pre-mix tank line repairs were completed. The pre-mix tank holding spring booster and the "A" second stage pump discharge valve were replaced. At 1630 hours flow at 51,200 ACFM entered the scrubber. A second leak developed in the first stage discharge header. Both leaks are

in a welded joint area. By 2130 hours the load was increased to 110,100 ACFM. The recycle rate to the first stage dropped from 4500 gal/min. to 3500 gal/min. at 2200 hours, but came back up by itself by 2330 hours.

The continuous monitoring and chemical analysis trailers resumed analyses.

A stearing committee meeting was held with representatives from EPA, Rumsford, Basic, PEPCO, Chemico and York.

Dec. 6 - The scrubber operated all day. Early in the day the centrifuge cake became very wet and sticky. A vibrator had to be kept on almost continually which caused low instrument air pressure. At 0435 hours a large clump of MgO plugged up the weigh feeder. The flow was cut to 117,800 ACFM because the pH started dropping. After the belt was cleared the load was increased. The flow was at 230,400 ACFM by 0700 hours and later increased as high as 240,600 ACFM. The centrifuge hopper required almost constant attention due to plugging. The grease fittings on the elevator belt were replaced. All of the stellited orifices were removed from the bleed line to the thickeners because the pipe failures in this area were attributed to the velocity increases across the plates. The DuPont SO_2 analyzer was repaired by the instrumentation shop.

There were no outlet readings at 1400 while the probe assembly was inspected.

Dec. 7 - The scrubber operated all day. The leaks in the first stage discharge header became much worse during the day. An unsuccessful attempt was made to patch the leaks with polyethylene. At 1100 hours the load was being reduced in order to install a blind in the first stage recycle line header. By 1700 hours the load was up to 188,400 ACFM. A leak developed in the spool piece in the first stage recycle line at the pinch valve location, and had to be patched.

The continuous monitoring trailer operated all day but had some pump and flow problems which were corrected as soon as they occurred. There were no 1500 and 1600 hour readings because of the pump outage.

Dec. 8 - The scrubber operated all day. The MgO weigh feeder belt ran off its track and had to be repaired. Another leak developed in the 6 inch spool line on the first stage recycle line and had to be patched. At 1530 hours Unit #3 had wet coal problems, and the scrubber load was cut to 146,400 ACFM from 188,400 ACFM. The centrifuge cake was still very wet and required much attention.

The continuous monitoring trailer had some problems with flow on the outlet mode. The probe had to be washed out, therefore the 0300 hour reading was omitted.

Dec. 9 - The scrubber operated all day. Early in the day the transition pipe between #1 and #2 feed screws plugged and the centrifuge feed was diverted long enough for the line to be freed. The impeller on the "B" pump had to be replaced. A piece of rubber in the north thickener bleed valve could not be freed so the tank was drained.

Dec. 10 - The scrubber operated all day. The continuous pH monitor was fluctuating but this was due to the coal feeder problems in the plant. New overload heaters of the correct rating were installed in the "B" MgO pump. The rotometer for the demister spray was removed and was found to be broken and frozen. The first stage recycle pumps were shut down to replace a 14 inch elbow. The elbow on the 6 inch plump-bob line was removed but a new one was not installed. A new leak developed in the centrifuge cover.

The continuous monitoring trailer was operational most of the day. No readings were taken from 1300 to 1600 hours due to a sample pump outage.

The chemical trailer performed a special study on pH vs. time, because of the differences between the continuous and bench meters. Results indicate the time between sampling and bench measurement was sufficient for the pH to increase 0.3 pH units.

Dec. 11 - The scrubber was operated only for a short time due to a planned shut down. At 0300 hours new leaks were noticed around the patches on the first stage bleed line to the thickener. The MgO tank was diluted and the flow was cut back in preparation for shut-down. At 0425 hours the I.D. fan was turned off. The north thickener was allowed to finish pumping out. The mother liquor pump valves were repaired and a new lined elbow was installed on the plumb-bob line. The blind was then removed from the top of the scrubber. The scrubber was ready for operation at 1600 hours but no PEPCO operators were available for work.

Dec. 12 - The scrubber was operated for only 2 hours today because a patch came off after start up. The rubber was cleared from the bleed valve in the north thickener and refilling began. Flue gas entered the scrubber at 1230 hours but at 1430 a high level was noted in the first stage, even though the bleed valve was completely open. Due to the high back pressure the patch on the 6 inch bleed line parted. The gas was routed out of the

scrubber at this time. The rakes on the thickeners were checked and found to be satisfactory.

York Chemists were informed they would have to move their laboratory.

Dec. 13 - The scrubber was put on-line at 1800 hours today. R. E. Donovan maintenance crews were on site in the morning. A 20 foot section of 6 inch rubber lined pipe was installed in the first stage bleed. The balance of the pipe was inspected and was found to have a baseball size blister in one section. A new section of pipe was fabricated to replace this section. A test of the pumps and first stage showed there was a restriction between the thickeners and scrubber. An inspection of a valve showed a ruptured liner. A liner was used from the north thickener valve to repair it. Gas entered the scrubber at 1810 hours at 228,400 ACFM. The flow was increased again at 1850 and was at 242,200 ACFM by 2200. The scrubber load may be limited as the boiler experienced wet coal conditions. The mother-liquor agitator kept malfunctioning. The problem was located in the motor or gearbox.

The York chemical lab was moved into a 36 foot trailer.

Dec. 14 - The scrubber operated all day. A leak developed in the spool piece that was installed at the 6 inch pinch valve location on the first stage recycle line. Maintenance personnel removed the gear box from the mother-liquor tank agitator. At 1600 hours the flow was cut to 120,300 ACFM, so that repair work to the lines could be performed. At 1705 hours the load was increased again to 153,600 ACFM.

The continuous monitoring trailer operated most of the day. An electrical short caused the main sampling line to burn out. A temporary replacement was installed. There are no 1800 to 2400 readings because of this electrical short.

The move of the chemistry laboratory was completed.

Dec. 15 - The scrubber operated all day. The centrifuge and its hopper had to be flushed out during the day. A leak developed in the second stage discharge header. At 1645 hours the flow was increased to 188,400 ACFM. At 2030 hours the flow was cut by 48,000 ACFM because the MgO tank nozzle plugged up and had to be cleared. The flow was maintained at 140,800 ACFM for the rest of the day.

The continuous monitoring trailer was semi-operational. The temporary sample line had intermittent freeze-up problems. An insulated line was put into service in

the evening. No readings were taken until 1400 hours.

Dec. 16 - The scrubber operated all day. Electricians were called when the "B" second stage recycle pump malfunctioned. They installed new overload heaters. The flow was dropped to 74,800 ACFM so the welder could repair leaks in the discharge header. At 1530 hours the boiler unit lost all coal feeders. The flow was cut to 80,000 ACFM. By 1840 hours the load was up to 165,900 ACFM.

Dec. 17 - The scrubber operated all day. Leaks developed near the top of the first stage vessel. Blanks were installed in the tangential nozzle lines to stop the leaks. A new leak developed in the second stage discharge header. During the afternoon the flow was increased to 197,600 ACFM, and a series of tests was carried out.

Three York Research personnel came in from Connecticut to perform particle mass testing.

Dec. 18 - The scrubber operated all day. The load was cut at 0830 hours because of the build up of very wet centrifuge cake in the dryer. The flow to the centrifuge was cut at this time so leaks could be welded in the centrifuge cover. A new leak developed in the second stage discharge header. While loading $MgSO_3$, approximately 1 ton was spilled due to a faulty gate. At 1930 hours, clumps of product started coming loose in the dryer. The load was cut and the centrifuge feed rate was reduced in order to clean the dryer.

The continuous monitoring trailer was semi-operational. The SO_2 unit went off-line at 0400 hours. The electronics technician from York Research was in contact with a Thermo Electron representative throughout the day attempting to fix the unit.

The stack testers from York Research performed four particle mass tests during the day.

Dec. 19 - The scrubber operated part of the day. At 1000 hours the second stage circulation was stopped so that second stage discharge header leaks could be welded. The gas was routed out of the scrubber at 1300 hours. While the scrubber was down, the dryer was cleaned with water. At 1535 hours the scrubber was back on-line at 173,000 ACFM and later flow was increased to 197,600 ACFM. The dryer discharge conveyor tripped and had to be reset. There continued to be a large build up in the dryer.

The continuous monitoring trailer was on-line except for the SO_2 monitor. (DuPont readings were used on the data sheets). A representative from TECO was scheduled

to fix the analyzer.

No stack testing was performed due to unsteady operating conditions.

Dec. 20 - The scrubber operated all day. A leak developed in the first stage vessel at the tangential spray nozzle level. The front band of rappers on the dryer were not hitting the drum. Attempts to tighten the rappers were unsuccessful. A 20 foot section of pipe to the upper pond developed a leak; it was replaced by a hose.

The continuous monitoring trailer was on-line too, but the SO_2 monitor was still not working. The CO_2 analyzer was down from 0600 to 0900 hours. The TECO SO_2 unit was back in service in late afternoon.

No particle mass tests were performed because the boiler load was too low.

Dec. 21 - The scrubber operated all day. At 0220 hours the flow was increased to 130,600 ACFM. Two leaks developed on stage nozzle distribution lines. The 8 inch pinch valve liner on the first stage tangential nozzle line failed.

The stack testers from York Research left today with plans to return in early January.

Dec. 22 - The unit was operated all day with one brief outage. At the start of the day, a leak developed in the first stage recycle line to the plumb bob on the north side of the scrubber. The scrubber was taken off-line at 0910 hours, and the pinch valve was repaired. The scrubber was on-line again at 1020 hours at 140,800 ACFM. The flow was increased to 146,400 ACFM by 1500 hours.

Dec. 23 - The scrubber operated in the beginning of the day. The liner in the pinch valve of the first stage recycle line ruptured. A leak also developed in a second stage discharge line. The gas was diverted from the scrubber at 0900.

York Research personnel departed for the holiday at 0900 hours.

Dec. 24 - The scrubber was not operated today. Shutdown procedures were completed during the day.

Dec. 25 - The scrubber was not operated today.

Dec. 26 - The scrubber came on-line at the end of the day. The second stage discharge header was welded, and the first stage spool piece with an orifice plate was installed. The pre-mix tank was cleared out during the day. An

electrician was called to check a relay on the second stage recycle pumps. Gas entered the scrubber at 2140 hours.

Dec. 27 - The scrubber operated all day. During the morning the load was cut so the pre-mix tank could be cleared. A mechanic adjusted the packing on the first stage and transfer pumps. The flow was increased throughout the day and was at 228,000 ACFM at 1900 hours.

York Research personnel resumed their testing at 0800 hours.

Dec. 28 - The scrubber operated all day. The centrifuge had to be diverted so the bucket elevator and the centrifuge hopper could be cleared. A leak developed on the first stage pump elbow and was plugged. Leaks also developed in the pH meter probe assembly and second stage suction header.

The SO_2 monitor in the York Research trailer was not working properly; DuPont readings were used from 1700 hours on.

Dec. 29 - The scrubber was operated for part of the day. A second hole on the first stage elbow had to be plugged. At 1000 hours the bucket elevator tripped; the inlet flow was reduced to allow the system to clear itself. At 1345 hours an upset occurred in the mother liquor and pre-mix tank. The gas was routed out of the scrubber at this time to repair the elbow leak for a third time. The ID fan would not restart because of a damper problem.

The SO_2 analyzer in the continuous monitoring was repaired and on line at 1050 hours.

Dec. 30 - The scrubber did not operate today. Final shut-down operations were carried out. The second stage suction header was removed, the water valve on the centrifuge deck was replaced, the gasket on the dryer ID fan was replaced, and the leaky elbow on the first stage was removed for repair.

JANUARY, 1975

Jan. 1 - The scrubber was not in operation today. The inside of the second stage was inspected and a large amount of crystals and dirt was found. It was concluded that some of the spray nozzles were plugged. The first stage elbow was replaced during the day.

Jan. 2 - Maintenance continued.

Jan. 3 - At the start of the day, maintenance was still being performed on the scrubber. Two of the flow meters froze; replacements were ordered. Gas entered the scrubber at 1545 hours and was at a flow of 266,200 ACFM by 2100 hours.

A new sample line for the continuous monitoring trailer was installed during the day. Leaks in fittings on the new line were eliminated but readings on the TECO unit appeared very low. The probable cause was a bad amplifier. Pump problems were encountered in the evening; therefore the readings for the day were inaccurate.

Jan. 4 - The scrubber operated until 0840 hours. A 3 inch drain valve on the second stage was plugged. The rake on the thickener was placed in service today.

The continuous monitoring trailer was not in operation.

Jan. 5 - The scrubber was not operated today. One of the second stage demisters was freed, and maintenance continued.

Jan. 6 - The scrubber was not operated today. Maintenance continued.

Jan. 7 - The scrubber was not operated until late in the afternoon. The second stage was inspected and found to have no leaks. The valves to the second stage cone and tangential sprays were blocked. The mother liquor agitator was repaired and re-installed. At 1735 hours gas entered the first stage. The second stage was not operated. The load was increased to 255,000 ACFM and was up to 279,200 ACFM by 2200 hours.

The continuous monitoring trailer had many problems. The sample pumps failed and part of the sample line burned out and had to be replaced.

Jan. 8 - The first stage was operating at the start of the day. At 1405 hours the gas was removed so a leak in the "B" discharge line could be repaired. The first stage was back on-line at 1600 hours and flow was up to 180,200 ACFM by 1700 hours.

At 1825 the load was raised 291,800 ACFM.

The continuous monitoring trailer operated well after 0300 hours. The NOx readings in the later part of the day were inaccurate due to a blocked capillary, which was discovered the next day.

Jan. 9 - The first stage of the scrubber operated until 1600 when the load was reduced because of coal feeder problems. A lubrication program was carried out during the day.

The continuous monitoring trailer operated with only small flow problems. The blocked capillary on the NOx monitor was corrected at 0900 hours.

Jan. 10 - The scrubber was operated until 0830. The gas was removed and repairs were made on the rubber lined elbow on the "B" first stage pump. A leak developed on an inner cone line and had to be repaired.

Jan. 11 - Repair work continued. A leak was found in the second stage bleed to the centrifuge. The first and the second stages of the scrubber came on-line at 1340 hours at 146,400 ACFM. The load increased to 197,600 ACFM at 2100. The centrifuge cover was leaking by the end of the day.

The continuous monitoring trailer operated well, except that the SO_2 readings for 1600 were not taken because the analyzer was being repaired.

Jan. 12 - The scrubber operated at a decreased load because of problems with the coal feeders in the station. At 1530 hours the MgO "A" pump suddenly lost pressure and the load was cut back to 188,400 ACFM; while cleaning and changing to the line "B" pump. The flow was then increased to 218,100 ACFM. The MgO weigh feeder was suspected to be incorrect.

Jan. 13 - The scrubber operated at this same level all day. Tests were performed to evaluate the accuracy of the MgO weigh feeder and it was found to be 25% high. A first stage inner cone developed a leak and was repaired. New leaks were noticed in the centrifuge cover.

The continuous monitoring trailer operated all day except for the outlet stack temperature monitor.

Jan. 14 - The scrubber operated between 202,000 and 220,000 ACFM until 1640 hours when it was shut down because the MgO supply had been exhausted. A number of problems were encountered before the shut-down. Among them were the centrifuge hopper constantly plugged, the first stage level controller froze up, the pre-mix tank partially solidified, and the wash hose for the centrifuge hopper froze.

The continuous monitoring trailer operated all day. No readings were taken at 0900 because the sample line was frozen. This problem was immediately corrected.

Jan. 15 -- The scrubber did not operate. The first stage was kept running to prevent it from freezing. New test buckets were installed on the bucket elevator. Maintenance and freeze-up precautions were carried out.

Jan. 16 -- The first stage was again kept running to prevent a freeze-up. A leak was discovered on the pH meter probe assembly. Three loads of MgO arrived during the night shift.

Jan. 17 -- The first stage was operated without gas to prevent its freezing. The "B" first stage pump failed to work correctly and was inspected. An 18 inch section of broken-off tangential spray nozzle was found in the pump. A new leak developed at the 10 inch tee to the tangential spray. At 1545 the first stage was shut down to save wear on the scrubber.

Jan. 18 - The first stage, without flue gas, was operated to avoid a freeze-up. The 10 inch line with the leak was removed. The ten tangential nozzles were inspected and the results were: six of the nozzles were completely missing, two were about to break and the other two were in fair condition. Because of the low plant output, 60 MW, the scrubber could not start up until 1315 hours. At 1400 the load was at 197,600 ACFM. At 1600 hours the dryer was fired but the screw conveyor at the top of the $MgSO_3$ silo kept tripping out. The operator was unable to inspect the screw because of the ice on the scaffolding. Flue gas was routed out of the scrubber at 1730 hours.

The continuous monitoring trailer operated properly for the time the scrubber was on-line.

Jan. 19 - The scrubber was operated for a brief period. The problem with the $MgSO_3$ conveyor was corrected and gas entered the scrubber at 1130 hours. At 1345 the flows and levels in the first stage could not be controlled due to a plugged line. At 1400 hours the gas was turned off.

Jan. 20 - The scrubber did not operate. Maintenance was performed on a valve liner.

Jan. 21 - The scrubber did not operate. The pumps and solids handling equipment were operated hourly to prevent a freeze-up.

Jan. 22 - The scrubber did not operate. Maintenance and freeze-up prevention were carried out throughout the day.

Jan. 23 - The scrubber came on-line during the afternoon. Before start-up work was completed on the thickener bleed line that plugged on Jan. 19. Gas entered the scrubber at 1445 hours. At 1615 hours the flow was at 120,300 ACFM. Problems developed in the MgO feeder and the flow had to be reduced to 87,000 ACFM to maintain the pH. At 2245 hours the flow was raised to 99,300 ACFM.

Jan. 24 - The scrubber operated all day. During the day leaks developed in the torus spray and in the first stage tangential spray header. At 0630 the flow was cut to 120,300 ACFM because of the low pH. By 0900 hours the flow was increased to 207,400 ACFM. Experiments with restricted flows were carried out on the second stage. The centrifuge hopper plugged and the load had to be cut to 135,700 ACFM but it was raised to 255,000 ACFM by 1600. At 1650 the bucket elevator tripped. The belts on the top of the elevator had to be replaced. The scrubber operated at 218,100 ACFM for the rest of the day.

Jan. 25 - The scrubber operated most of the day. The centrifuge hopper was washed out to avoid plugging. The gas was removed at 1500 hours to insure that the scrubber would be able to operate for a visit by Chemico management on Jan. 27.

Jan. 26 - The scrubber did not operate. Leaks were patched and new belts were installed on the bucket elevator. Pumps and solids handling equipment were operated hourly to prevent a freeze-up.

Jan. 27 - The scrubber was operated for part of the day. Gas entered the scrubber at 0525 hours. The load was changed many times during the day; the maximum load was 309,200 ACFM. The scrubber was operated in both Mode I (gas after precipitator) and Mode II (gas before the precipitator). When in Mode II it was noted the centrifuge cake was very dirty from carry-over fly ash. At 1540 the gas was removed from the scrubber.

The continuous monitoring trailer operated well; except that the inlet velocity readings before 0900 are inaccurate because of a crimped pitot line.

Jan. 28 - The scrubber did not operate. Final scrubber shut-down procedures were carried out.

The boiler (Unit #3) was shut down for a major turbine overhaul which took several months. The scrubber did not operate until August 11, 1975, when operation was planned for only 3 to 4 weeks to consume the MgO on hand.

The supply of MgO was limited due to the shut-down of the Essex Regeneration Facility in Rhode Island.

Jan. 29 -- The buckets that were installed on Jan. 15th were removed and inspected. They were found to be bent out of shape to the extent that they were ineffective.

AUGUST-OCTOBER, 1975

Aug. 11 - The scrubber began operating at 1403 hours; however, due to the outlet damper sticking, the gas flow was shut off. At 1435 gas entered the scrubber at 87,000 ACFM. When steam was admitted to the MgO slurry tank, the control valve cracked; and operation continued without steam. The scrubber operated the rest of the day at 218,100 ACFM.

The continuous monitoring trailer had many problems. Water in the gas conditioning system overflowed and flooded the sample lines.

NOTE: Due to limited manpower, scrubber operating parameters were taken only every 2 hours.

Aug. 12 - The scrubber operated all day except for a brief shut-down. The outage was to replace some first stage bleed lines.

The continuous monitoring trailer experienced more flooded lines because the condensers failed during the night.

Aug. 13 - The scrubber operated most of the day at between 197,600 and 218,100 ACFM.

The continuous monitoring trailer was off line because of the problems with excessive moisture in the sampling lines.

Aug. 14 - The scrubber operated all day. At the start of the day, the flow was cut to 120,300 ACFM and then further reduced to 82,900 ACFM because of a build up of dryer product. By 2400 hours it had been raised to 180,200 ACFM.

The continuous monitoring trailer was not on line because of gas conditioner malfunctions.

Aug. 15 - The scrubber operated for only a short time today. The flow was increased to 207,400 ACFM by 0225 hours. Because of a build up of the dryer product, the flow was reduced and at 0400 the scrubber was shut down.

Repair work continued on the continuous monitoring trailer.

Aug. 16 - Repair work was initiated on the dryer drum. The boiler developed a tube leak at 0018. Repairs on the boiler tube were complete at 2010.

Aug. 17 - Repair work on the scrubber continued.

Aug. 18 - Repair work on the scrubber continued.

Aug. 19 - Repair work on the scrubber continued.

Air conditioning maintenance people repaired the condensing units on the continuous monitoring sample system.

Aug. 20 - Repair work on the scrubber continued. The boiler developed a reheater tube leak at 0100. This was repaired by midnight.

Aug. 21 - Repair work on the scrubber continued.

Aug. 22 - Repair work on the scrubber was completed. Gas entered the scrubber at 1430 hours at 153,600 ACFM. The flow was raised to 197,600 ACFM by midnight.

The continuous monitoring system operated well after start up.

Aug. 23 - The scrubber was at a flow of between 197,600 and 228,400 ACFM for most of the day. At 1800 hours the bucket elevator tripped several times but was finally restarted. At 2300 hours, centrifuge clogging problems forced a scrubber shut-down.

The continuous monitoring trailer was shut down at 0500 because of moisture problems. The outlet mode only was operational from 1600 hours.

Aug. 24 - The centrifuge hopper was washed out.

Aug. 25 - The centrifuge cleaning and repair was completed. Gas entered the scrubber at 1330 at 173,100 ACFM. By 1600 the load was increased to 180,200 ACFM.

Air conditioner repair people serviced the conditioning units on the continuous monitoring trailer. The outlet mode was operational at start up and the inlet mode on-line at 2200 hours.

Aug. 26 - The scrubber was operated until 1830. At this time it was decided to shut the second stage down and adjust the weir height in the centrifuge. It was hoped that this would produce a dryer centrifuge cake. The first stage was operated the remainder of the day.

The continuous monitoring system operated all day. At 2030 hours it was placed on outlet mode only for the night.

Aug. 27 - The first stage of the scrubber operated until 1530 hours when it was taken off line to repair leaks in the first stage recycle lines.

The continuous monitoring trailer operated on outlet mode only until 1200 hours. Repairs on the inlet conditi oner were completed and inlet/outlet monitoring resumed.

Aug. 28 -- Shut-down procedures were carried out on the scrubber and continuous monitoring trailer.

Aug. 28-
Sept. 11 Repairs on scrubber continued.

Sept. 11 -- Scrubber operation was limited to the first stage in order for the plant to conduct a study on particle removal using both the electrostatic precipitator and the scrubber. The first stage began operation at 0925 and shut down 12 hours later for repairs on the boiler and ESP.

Sept. 12 -
Sept. 18 Particle removal study continued.

Sept. 19 - Repairs planned on stirrer bearing on MgO slurry tank
Sept. 20 agitator. First stage in operation for a total of 84 hours during study

Oct. 19 - Wait for delivery of bearing.

Oct. 20 - Scrubber startup of both stages. The centrifuge was completely "cemented" with product and during the startup the pins were sheared. Maintenance and further repair of the unit was judged too costly by the plant representatives and the program was terminated.

APPENDIX D

METHODOLOGY

CHEMICAL ANALYSES METHODOLOGY

% FREE WATER ON CENTRIFUGE CAKE

A portion of the sample was weighed in a tared vessel. Several aliquots of acetone were added to wash the sample which was stirred and separated. The sample was transferred to a tared watch glass, oven-dried for 30 minutes and re-weighed to obtain the oven-dried sample weight.

Calculation: % Free water = 100 - % solids

where: $$\% \text{ Solids} = \frac{\text{wt. of oven-dried sample}}{\text{wt. of original sample}} \times 100$$

% COMBINED H_2O on CENTRIFUGE CAKE AND DRYER PRODUCT

A 10.0 gr portion of the oven-dried sample was placed on an OHAUS moisture balance for 50 minutes. When complete, % moisture was read from the calibrated scale.

pH

The pH of the samples was taken using a Corning Research pH meter. The meter was first standardized using two standard buffer solutions and temperature compensated. Readings on the meter were then taken $\pm$ 0.01.

DENSITY DETERMINATION ON MOTHER LIQUOR, 2nd STAGE BLEED, MgO SLURRY

A 10.0 ml (2 ml) sample was placed in a tared graduated tube and weighed on an analytical balance. This analysis was always performed in triplicate.

Calculation: $$\frac{\text{wt. sample}}{\text{ml sample}} = \text{Density in gms/ml.}$$

APPARENT DINSITY: CENTRIFUGE CAKE AND DRYER PRODUCT (As Received)

A 100 ml plastic cup was tared and filled loosely with sample to the mark. The weight was taken on the triple beam balance and evaluated:

grams/100 ml = weight/100 ml

SUSPENDED SOLIDS (mg/l)

200 mls of sample filtered through a tared millipore filter, dried in an oven for 1 hour @ 125°F and weighed.

Calculation: $$\text{mg/l S.S.} = \frac{\text{mgs S. solids}}{\text{200 mls sample}} \times 5$$

% MgO IN MOTHER LIQUOR, MgO SLURRY AND SECOND STAGE BLEED

A portion of the sample was collected into a graduate centrifuge tube. The exact volume was noted and the sample was analytically transferred to a beaker. A reaction with 3% H_2O_2 was induced by boiling and a quantity of H_2SO_4 was added.

For MgO slurrys add 25 ml of 2.512N H_2SO_4

For Mother Liquor, 2nd stage bleed add 10 ml of 2.512N H_2SO_4

The solution was stirred and boiled for 5 minutes, then diluted. When cooled, a methyl purple indicator was added and the solution was titrated with NaOH to a distinct green endpoint.

$$\text{Calculation: } \% \text{ MgO} = \frac{(\text{ml } H_2SO_4 \times N) - (\text{ml NaOH} \times N)}{\text{mls sample}} \times 2.016$$

% MgO DETERMINATION ON CENTRIFUGE CAKE (OVEN DRIED), DRYER PRODUCT 2nd STAGE BLEED SOLIDS, MOTHER LIQUOR SOLIDS, MgO BELT

These samples were prepared as above except the quantity of H_2SO_4 which was added.

For MgO Belt sample add 25.0 ml of 2.512 N H_2SO_4

For the rest add 50.0 ml of 0.50 N H_2SO_4

$$\text{Calculation: } \% \text{ MgO} = \frac{(\text{mls } H_2SO_4 \times N) - (\text{mls NaOH} \times N)}{\text{sample wt.}} \times 2.016$$

CHLORIDE

Liquid, Homogeneous

A portion of the sample was treated with an aliquot of HNO_3 and $AgNO_3$ and allowed to become turbid. The concentration of chloride was calculated from the turbidimetric calibration curve, FIGURE D-1 and the turbidity reading on the meter.

Solids and Slurrys

A weighed sample was treated with an aliquot of HNO_3 and heated to complete dissolution. The contents were then diluted to a known volume and an aliquot was treated with $AgNO_3$. The resultant turbidity was read on a meter and calculated from the calibration curve, FIGURE D-1.

$$\text{Calculation: } \% \text{ Cl-} = \frac{\text{mg/l} \times \frac{\text{vol.}}{1000} \times 100}{\text{wt.} \times 1000}$$

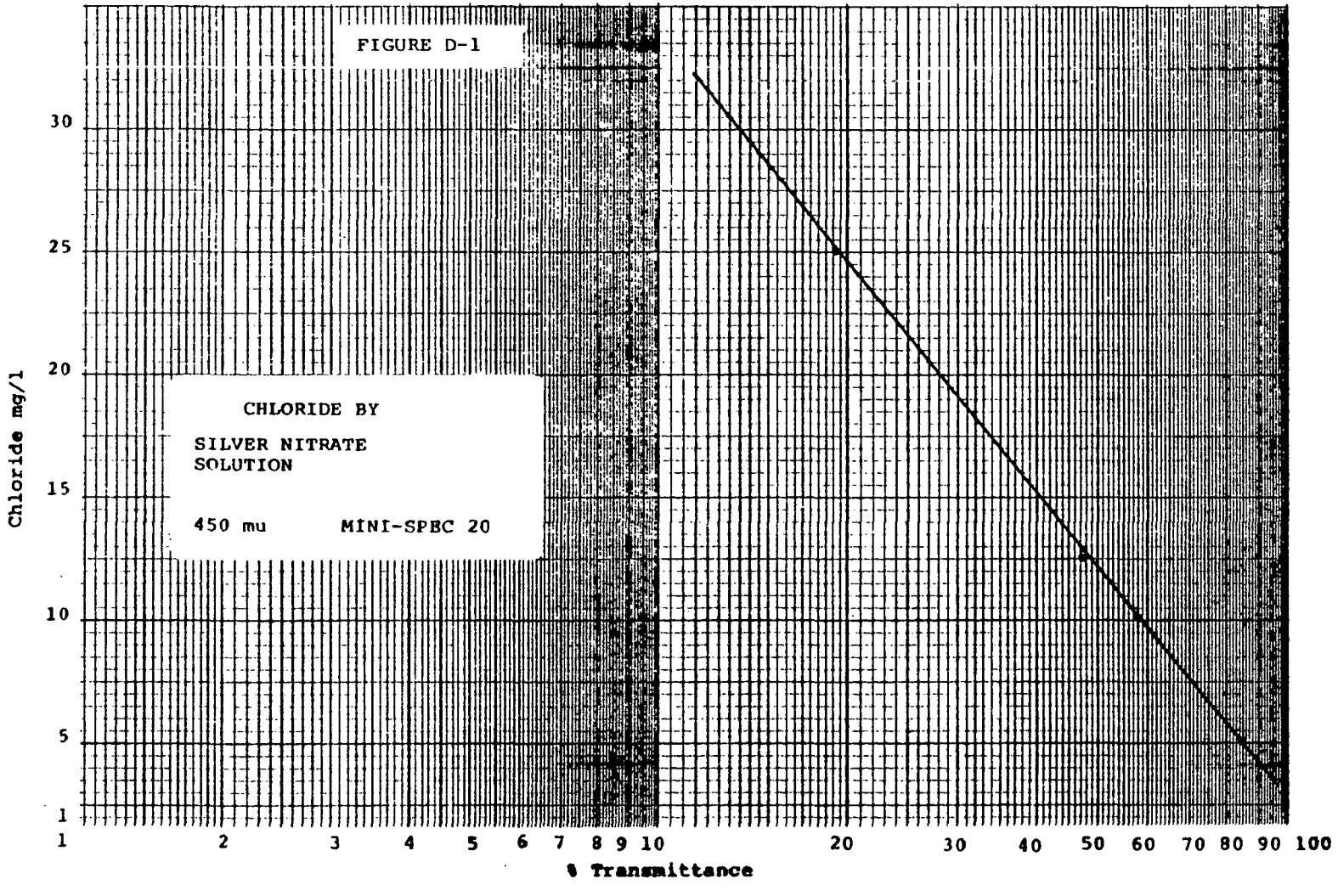


FIGURE D-1
CHLORIDE BY
SILVER NITRATE
SOLUTION
450 mu
MINI-SPEC 20
Chloride mg/l
30
25
20
15
10
5
1
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
% Transmittance

Percent Magnesium

The percent magnesium was determined by a titration with a standard solution of disodium ethylenediaminetetraacetic acid solution (EDTA). The pH was adjusted to 10 ± 0.05. A suitable sample volume was chosen, the pH adjusted and titrated with EDTA solution. The end point of the titration was determined by the addition of Eriochrome Black T, because the indicator color was red in the presence of magnesium and blue when the cations are completely complexed with the EDTA. Calculations were made from the amount of titrant consumed by the sample. The amount of magnesium was determined on the filtrate portion of the samples. Calcium was first precipitated out of solution as the oxalate. The magnesium was calculated from the amount of EDTA consumed and reported in gr/l.

Magnesium content in solids was determined by treating a weighed portion of the sample with 1:4 HNO_3 and heated until dissolution was complete. The solution was then diluted and an aliquot treated with NH_4O_4, oxalic acid and filtered. The solution was buffered to a pH of 10.0 ± 0.02 and titrated as above.

$$\text{Calculation: } \% \text{ Mg} = \frac{\text{mg/l} \times \frac{\text{vol.}}{1000} \times 100\%}{\text{wt.} \times 1000}$$

% SOLIDS (GRAVIMETRIC) ON 2nd STAGE BLEED AND MOTHER LIQUOR

An aliquot of the sample was placed in a preheated, tared bottle and weighed. The sample was shaken, filtered, and re-weighed. The filter was then washed repeatedly with portions of acetone and dried in an oven at 135°F for 30 minutes. The sample was then re-weighed and calculated as follows:

$$\% \text{ Solids} = \frac{\text{wt. dry solids}}{\text{sample wt.}} \times 100$$

% $MgSO_4$ on 2nd STAGE BLEED FILTRATE

The filtrate saved from the % solids analysis was allowed to sit for 1-2 hours to allow any solids to settle out. 10.0 mls was pipetted into a tared vessel, and weighed. From this the density equalled 0.1 x weight of 10 ml.

Calculation: The % $MgSO_4$ is then read from the graph on the following page (data from Perry's Engineering Handbook). (Figure D-2)

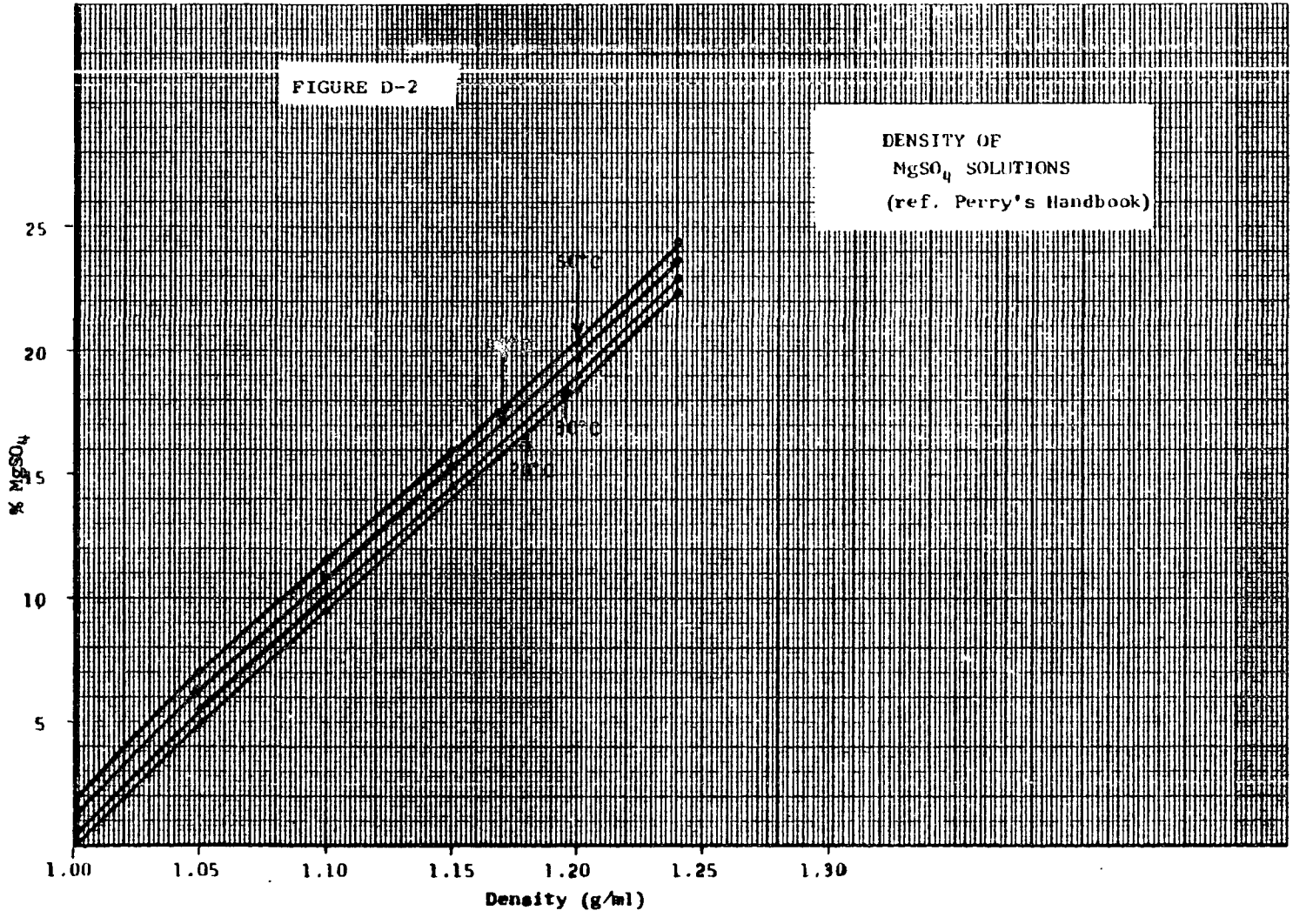


FIGURE D-2
DENSITY OF
MgSO4 SOLUTIONS
(ref. Perry's Handbook)
50°C
30°C
25
20
15
10
5
% MgSO4
1.00
1.05
1.10
1.15
1.20
1.25
1.30
Density (g/ml)

Sulfate

Sulfate was determined on a filtered sample because particulate matter interferes with the gravimetric method. Determinations made on solid samples were performed after the potassium carbonate fusion (1.2) and dissolution. The clarified sample was acidified to a pH of 4.5-5.0, an additional amount of hydrochloric acid was then added. This solution was heated to boiling and, while being stirred gently, a solution of barium chloride was added slowly until precipitation appeared complete; then a 2 ml excess of barium chloride was added. The precipitate was digested at 80-90°C, and to insure proper crystallization of the $BaSO_4$ the solution was let to stand overnight. The precipitate was filtered and washed with distilled water until free of chloride. The $BaSO_4$ crystals and the filter were dried and ignited at 600°C for one hour, cooled in a dessicator and weighed. The amount of sulfate present in the sample was calculated from the equation:

$$\text{mg } SO_4/l = \frac{\text{mg } BaSO_4 \times 411.5}{\text{ml of sample}}$$

% $MgSO_4$ in DRYER PRODUCT, CENTRIFUGE CAKE (OVEN-DRIED) AND MgO BELT SAMPLES

A weighed portion of sample was diluted and treated with an aliquot of 1:1 HCl and boiled for several minutes. The hot solution was filtered analytically. A portion of the cooled solution was treated with a HACH Sulfaner reagent and placed in a colorimeter cell. The solution was allowed to react and then shaken. The absorbance was then read on the colorimeter, and calculated from the calibration curve (Figure D-3).

Calculation: % $MgSO_4$ = meter reading x 0.3133

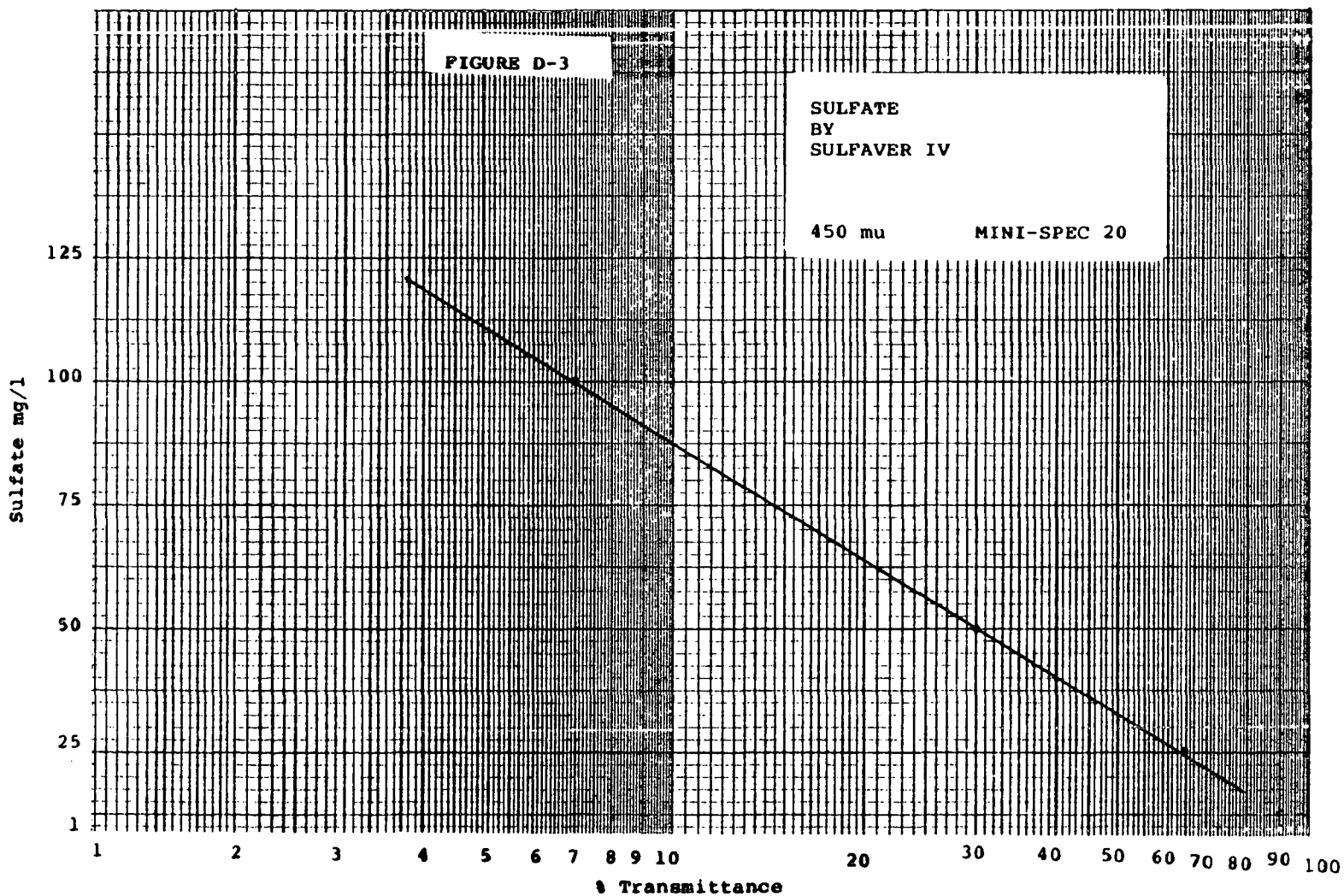


FIGURE D-3
SULFATE
BY
SULFAVER IV
450 mu
MINI-SPEC 20
Sulfate mg/l
125
100
75
50
25
1
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
% Transmittance

% $MgSO_3$ IN CENTRIFUGE CAKE AND DRYER PRODUCT

The percent sulfite in the solid samples was determined titrimetrically. A weighed portion of the sample was treated with a normal solution of sodium and diluted with water. Immediately before titration with 0.1N solution of sodium thiasulfate, an aliquot of 1:1 HCl was added. The solution was titrated to a pale yellow and a few drops of starch indicator added. The titration continued until a clear endpoint was obtained.

$$\text{Calculation: } \% MgSO_3 = \frac{(\text{ml } I_2 \times N\ I_2) - (\text{ml } Na_2S_2O_3 \times N_{Na_2S_2O_3}) \times 5.215}{\text{sample wt.}}$$

% $MgSO_3.6H_2O$ in SECOND STAGE BLEED AND MOTHER LIQUOR

A portion of the sample was collected in a graduated centrifuge tube and the exact volume noted. The contents were transferred analytically, diluted, and treated with 2.5 normal H_2SO_4 dropwise to a pH of 4.5-5.0. An aliquot of KI-starch indicator was added and the solution titrated with standard KIO_3 solution to a faint blue color. The solution stirred with a magnetic stirrer and titrated carefully to a deep blue endpoint.

$$\text{Calculation: } \% MgSO_3.6\ H_2O = \frac{\text{ml } KIO_3 \times N_{KIO_3} \times 7.08}{\text{ml sample}}$$

% Sulfite

As above with the following calculation:

$$\%SO_3 = \frac{\text{ml } KIO_3 \times N_{KIO_3} \times 2.668}{\text{ml sample}}$$

CONTINUOUS MONITORING
SAMPLING PROCEDURES AND
WET TEST RESULTS

MONITORING HARDWARE

The mobile emissions measuring laboratory consisted of six separate monitoring devices for continuous 24 hour measurement of sulfur dioxide, nitrogen oxides, carbon dioxide, carbon monoxide, oxygen, and inlet velocity pressure. Each unit was selected for its accuracy, reliability, and applicability. In addition to these units, inlet duct, outlet duct and sample line temperature were monitored with chromel-alumel thermocouples and digital readouts. All of the above systems had Rustak strip chart recorders operating continuously. A brief description of each of the emissions monitoring instruments follows.

THERMO-ELECTRON CORPORATION MODEL 10B CHEMILUMINESCENT $NO-NO_x$ ANALYZER

The TECO $NO-NO_x$ Gas Analyzer provides a sensitive and accurate means of continuously measuring the concentrations of nitric oxide (NO) and total oxides of nitrogen ($NO + NO_2$) in stack gases. The heart of the analyzer is the cylindrical reaction chamber Figure D-4 where sample gas containing NO molecules mixes with O_3 molecules from the ozone generator. Electronically excited NO_2 molecules are created which emit light (chemiluminescense) as the orbital elecrons decay to their ground state. Specifically:

$$NO + O_3 \longrightarrow NO_2 + O_2 + h\nu$$

In operation, dry filtered air is drawn into the instrument and a portion is converted to O_3 in an ozone generator. Separate capillary tubes carry the mixture of O_2 and O_3 and sample gas into the reaction chamber where mixing occurs. A vacuum pump keeps the reaction chamber pressure at a constant -25 inches of mercury. The chemiluminescent signal in the reaction chamber is deflected by a high sensitivity photomultiplier tube; the deflection of which is limited to the narrow wavelength band produced only by the $NO-O_3$ reaction. The signal as it leaves the tube enters an electrometer amplifier which further amplifies the signal and converts it to voltage. The amplifier voltage output powers the meter and the strip chart recorders.

To measure NO concentrations, the sample gas to be analyzed is blended with O_3 in the reaction chamber. The resulting chemiluminescence is monitored through an optical filter by a high sensitivity photomultiplier position at one end of the reactor. The output from the photomultiplier is linearly proportional to the NO concentration.

To measure NO_x concentrations the sample gas is diverted through a stainless steel heated coil which converts any NO_2 to NO before the sample enters the reaction chamber. The chemiluminescent response is linearly proportional to the NO_x concentration entering the converter.

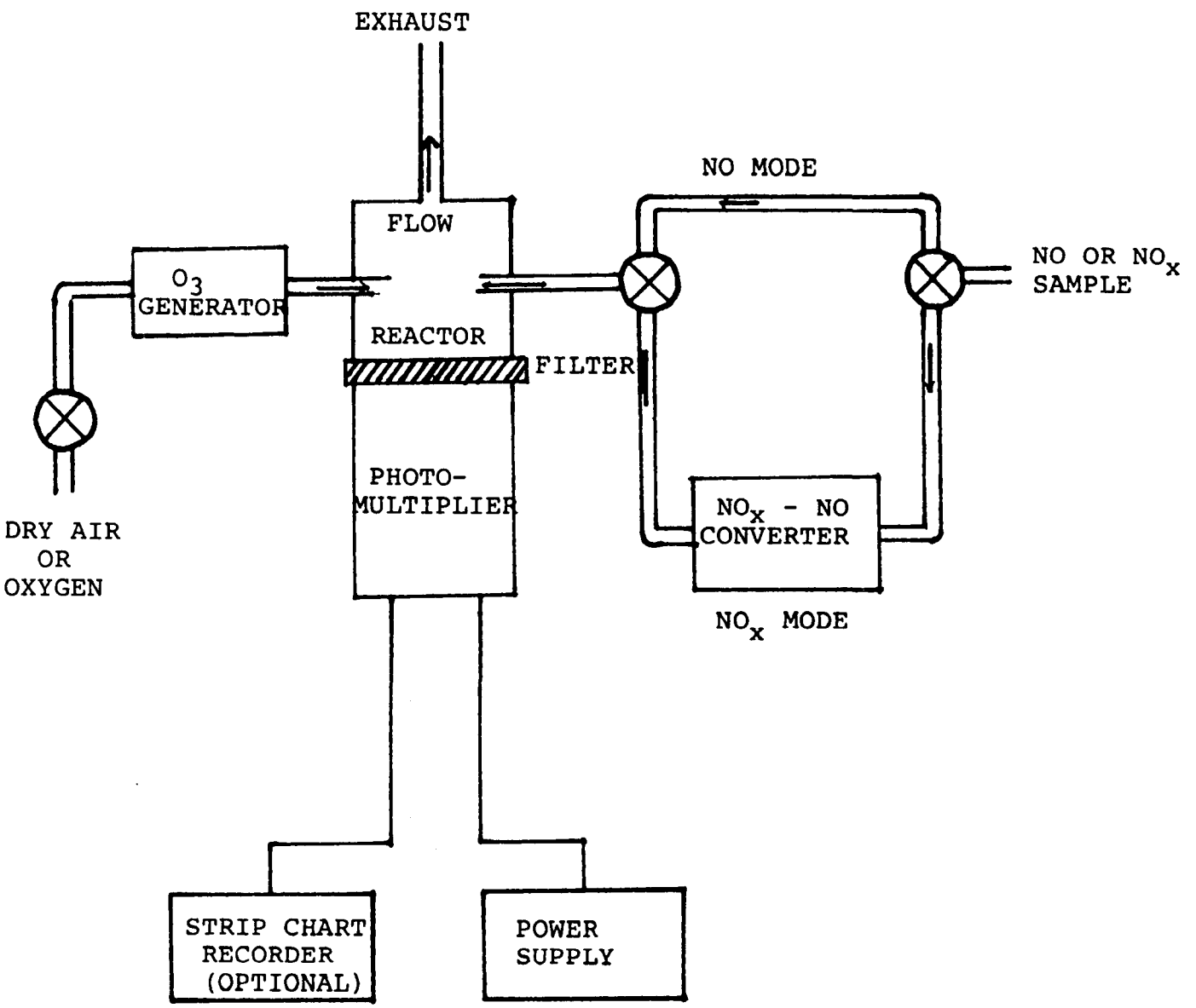


FIGURE D-4

Chemiluminescent NO-NO_x Gas Analyzer Conceptual Schematic.

INSTRUMENT CALIBRATION

All analyzers were calibrated daily in the manner specified by the manufacturer of the instrument. Calibration Gas was stored in the rear of the York Research Corporation Monitoring trailer and was injected at specifically controlled rates from the master control panel located within the trailer proper.

In addition to the standard calibration methodology, the combination gas was injected up an auziliary sample carrying line into the probe and then returned to the analyzers through the usual passageways. Utilizing this method, York engineers could determine if probe or sample line leakage existed.

As a final check on the instruments, York Research performed wet chemical testing under strict EPA guidelines (Tables D-1 through D-5). Samples were taken simultaneously at the inlet position and the trailer's analyzer lead-in, and then again at the outlet position and the trailer's analyzer lead-in. The following methods were used to verify instrumentation:

Sulfur Dioxide: EPA Method #6
Nitrogen Oxide: EPA Method #7
Carbon Dioxide, Oxygen, and Carbon Monoxide: EPA Method #3

SO_2

The SO_2 sampling and analysis was performed in accordance with the specifications outlined in the Federal Register, Vol. 36, No. 247 - Thursday, December 23, 1971, and designated as Method 6 - "Determination of Sulfur Dioxide Emissions From Stationary Sources". This method basically consists of pulling the stack gas sample through a heated, glass-lined probe and bubbling it through a series of four midget impingers, reference Figure 1.

The first impinger contains 15 ml of isopropanol, which will scrub the SO_3 and H_2SO_4 out of the sample gas stream. The next two impingers each contain 15 ml of hydrogen peroxide, which is used to oxidize the SO_2 to SO_3 and react with the SO_3 to form H_2SO_4. The fourth impinger remains empty. The SO_2 samples were analyzed on-site by titration to a pink end-point using standardized barium chloride.

Nitrogen Oxides

Nitrogen oxide samples were taken using Method 7 - "Determination of Nitrogen Oxide Emissions From Stationary Sources" as printed in the Federal Register, Vol. 36, No. 247 - Thursday, December 23, 19-1. The procedure for obtaining the sample is to evacuate a two liter glass flask to approximately 26 inches of mercury. The flask, containing 25 ml of a sulfuric acid - hydrogen peroxide solution, is evacuated and leak-tested. Stack gas is then pulled into the flask by vacuum and a complex of H_2SO4/NO_2

is formed. Any NO that is present in the stack gas is oxidized to NO_2 with available oxygen from the hydrogen peroxide. See Figure 5.

Analysis of the sample is performed by reaction with phenoldisulfonic acid in a basic medium. A yellow nitrate is formed which has a color proportional to the concentration. The absorbance is then read by a spectrophotometer at 400 nm.

TABLE D-1. EMISSION TESTING WITH CONVENTIONAL EQUIPMENT

Date	Parameter	Location	Method EPA # *
11-26-74	SO_2	Outlet (Duct)	6
	SO_2	Outlet (Trailer	6
	O_2, CO_2 and CO	Outlet (Duct)	3
	"	Outlet (Trailer)	3
	"	Outlet (Instruments)	3
12-6	SO_2	Inlet/Outlet	6
12-9	SO_2	Inlet/Outlet	6
12-10	SO_2	Inlet	6
12-14	SO_2	Inlet/Outlet	6
12-17	SO_2	Inlet/Outlet	6
12-18	SO_2	Inlet	6
12-19	SO_2	Inlet/Outlet	6
12-8	O_2 and CO_2	Inlet (Duct)	3
	"	Outlet (Duct)	3
	"	Inlet (Trailer)	3
	"	Outlet (Trailer)	3
	"	Analyzer (Inlet)	3
	"	Analyzer (Outlet)	3
12-18	4 particulate mass	Inlet/Outlet	5
12-20	2 " "	"	5
12-21	1 " "	"	5
1-7-75	SO_2	"	6
1-8-75	SO_2	"	6
1-9-75	SO_2	"	6
1-10-75	SO_2	"	6

* Federal Register, Dec. 23, 1971, Vol. 37, No. 247

TABLE D-2. WET CHEMICAL VERIFICATION OF INSTRUMENTS

SO_2 - EPA Method 6, 11/26/74

1300:	Outlet at Duct	-	170 ppm
	Teco Model 40	-	150 ppm
1330:	Outlet at Trailer	-	161 ppm
	Teco Model 40	-	150 ppm

O_2, CO_2, CO - EPA Method 3, 11/26/74

		% O_2	% CO_2	%CO
1400:	Inlet at Duct	6.5	13.8	0.0
	Inlet at Trailer	6.6	13.5	0.0
	Inlet at Instruments	6.2	13.6	0.0
1430:	Outlet at Duct	8.0	12.5	0.0
	Outlet at Trailer	8.0	12.4	0.0
	Outlet at Instruments	7.9	12.6	0.0

TABLE D-3. INSTRUMENT CALIBRATION - JANUARY 1975

Date	Time	Type of Reading	SO_2 (ppm)	NO_x (ppm)	% CO_2	% O_2
1/8/75	0840	Desired	1000	520	15.0	5.0
		Actual	1000	620	14.0	6.2
		Difference	--	+100	-1.0	+1.2
1/10/75	0025	Desired	1000	500	15.0	5.0
		Actual	1000	540	13.5	4.8
		Difference	--	+40	-1.5	-.2
1/11/75	1200	Desired	1000	520	15.0	5.0
		Actual	1000	520	15.0	5.0
		Difference	--	-	--	-
1/12/75	0025	Desired	1000	500	15.0	5.0
		Actual	910	500	16.0	5.0
		Difference	-90	-	+1.0	-
1/14/75	0125	Desired	1000	520	15.0	5.0
		Actual	1000	515	14.0	5.0
		Difference	--	-5	-1.0	-
1/24/75		Desired	1000	500	15.0	5.0
		Actual	1100	500	15.0	4.9
		Difference	+100	-	--	-0.1
1/25/75	0505	Desired	1000	500	15.0	5.0
		Actual	1000	420	11.0	5.0
		Difference	--	-80	-4.0	-
1/27/75	0525	Desired	1000			
		Actual	950			
		Difference	-50			

TABLE D-4. GAS ANALYSES - EPA METHOD #3*
December 8, 1974 Time: 1415 hrs.

Location	% CO_2	% O_2
Inlet Duct	12.0	6.0
	12.0	6.5
	12.3	5.5
Outlet Duct	11.8	6.0
	11.5	6.5
	11.5	6.8
Trailer Inlet	12.0	6.5
	12.0	6.5
	11.8	5.5
Trailer Outlet	11.8	6.3
	11.8	6.5
	11.5	6.8
Analyzer Inlet	12.5	6.5 (1500 hrs)
Analyzer Outlet	12.7	6.8 (1400 hrs)

* Federal Register (Vol. 37, No. 247, December 23, 1971)

TABLE D-5. SO_2 WET TESTS - EPA METHOD #6*

Date	Time	ppm SO_2 Wet Test Inlet	ppm SO_2 Wet Test Outlet	ppm DuPont In	ppm DuPont Out	ppm TECO In	ppm TECO Out
12/6	1200	945	154	***	-	930	145
12/9	1000	1030	270	1020	234	1050	220
12/10	1300	1166	N	--	N	800**	N
12/14	0300	1185	228	1140	216	1200	230
12/17	0300	833	122	840	132	800	130
12/18	0200	***N	132	N	156	N	150
12/19	0500	1122	193	1140	204	-	-

* Method 6 - Federal Register, (Vol. 37, No. 247, December 23, 1971)
** Leak in main sample line
*** Not in service
**** Not sampled

TABLE D-6. WET TESTS - JANUARY 1975

Date	Time	SO_2 ppm Wet* Inlet	SO_2 ppm TECO Inlet	SO_2 ppm Wet* Outlet	SO_2 ppm TECO Outlet
1/7/75	0330	1042	1050	126	133
1/7/75	0600	1137	1160	1140	1160
1/7/75	2300	1147	1160	1032	1040
1/8/75	1830	1286	1300	1299	1320
1/9/75	0200	892	900	824	825
1/10/75	0400	791	800	716	700

* Method 6 - Federal Register (Vol. 37, No. 247, Dec. 23, 1971)

APPENDIX E

TRANSIENT CONDITIONS

SUMMARY OF BOILER RELATED TRANSIENT CONDITIONS

Condition	Date	Duration of Transient Cond.	Previous SO_2 Inlet (ppm)	Transient Cond. SO_2 Inlet(ppm)	% Change in SO Inlet	Previous* SO_2 Outlet (ppm)	Transient Cond. SO_2 Outlet(ppm)	% Change in SO Inlet	Previous* % SO_2 Removal Efficency	Transient Cond. % SO_2 Rem.Eff.	% Change in Eff.
Drop in Boiler load wet coal	12/8	24 hrs. (0900-0800, 12/8-12/9	980	1109	+ 13%	143	273	+ 91%	85.4	75.3	-10.1%
Rising Boiler Load	12/9	14 hrs. (0900-2400, 12/9)	1109	925	- 16.6%	273	207	-24%	75.3	77.6	+2.3%
Coal Feeder Problem Wet Coal	12/20	21 hrs. (2400-2000, 12/20)	1269	1060	-16.5%	232	232	-	81.7	78.2	-3.5%
Coal Feeder Problem	12/17	2 hrs. (0800-0900, 12/17)	814	785	-3.6%	124	183	+47.6%	84.7	75.7	-9.0%
Coal Feeder Problem	1/12	10 hrs. (2400-0900, 1/11-1/12	999	1098	+9.9%	141	155	+9.9%	85.8	85.8	-

* Previous refers to steady state conditions existing before the transient condition.

TRANSIENT CONDITIONS - CAUSES

Condition	Date	Cause	Scrubber Operator Response
Centrifuge Repair	11/15/74	Cover leak - abrasive material in centrifuge feed wearing on the carbon steel	Reduction in fan rpms and MgO slurry feed flow
Centrifuge Diversion	1/14/75	Maintenance procedure - wash out the chute to prevent clogging	None
Centrifuge Diversion	12/28/74	Clogged hopper - wet centrifuge cake, possibly due to improper weir height	None
1st Stage Outage	12/7/74	Leak - 1st Stage recycle lines. Breaks in rubber lining exposed carbon steel pipe to low pH/high abrasive content liquid of 1st stage	Initial reduction of fan rpms (1 hr.), and then complete first stage shutdown
2nd Stage Outage	12/16/74	Leak in discharge header - abrasive action of the solids laden slurry	Fan rpms reduced and complete second stage shutdown
2nd Stage Outage	12/19/74	Repair recycle header - 20" pipe very thin due to abrasive action; holes easily formed	Fan rpms reduced and complete second stage shutdown
Drop in boiler load	12/8/74	Wet coal - high surface moisture that reduced pulverized mill outlet temperatures to below the 150°F minimum needed to maintain an adequate drying cake.	Boiler operators reduced fan rpms
Rising Boiler Load	12/9/74	Partial alleviation of wet coal problem	Fan rpms increased
Boiler feed problem	12/20/74	Wet coal - agglomeration of coal particles before the pulverizer	Fan rpms reduced

DURATION OF TRANSIENT CONDITIONS

Condition	Date	Duration of Transient Condition	Period of Emission Influence
Centrifuge Repair	11/15/74	2 hrs. 40 min. for repair	5½ hrs.
Centrifuge Diversion	1/14/75	< 1 hr.	-0-
Centrifuge Diversion	12/28/74	< 1 hr.	-0-
1st Stage Outage	12/7/74	50 min. actual outage time	3 hrs.
2nd Stage Outage	12/16/74	1 hr. 15 min. outage time	3 hrs.
2nd Stage Outage	12/19/74	3 hrs. of 2nd Stage outage, then complete scrubber shutdown for 2 hrs.	6 hrs.
2nd Stage Outage	8/26/74	> 6 hrs., 2nd stage out until end of testing on Aug. 27	> 6 hrs.
Drop in boiler load-wet coal	12/8/74	24 hrs.	24 hrs. - rising boiler load followed
Rising Boiler Load	12/9/74	2 hrs. for boiler load to reach previous levels	> 48 hrs. before gas flow and efficiencies back to previous levels
Coal Feeder Problem	12/17/74	2 hrs.	3 hrs.
Coal Feeder Problem	1/12/75	> 24 hrs. before boiler load back to previous levels	0 hrs.; no adverse effect on unit operation
Boiler Feed Problem - Wet Coal	12/20/74	21 hrs.	> 24 hrs.

* RANK OF TRANSIENT CONDITIONS - EMISSION INFLUENCE

Inducing Greatest Efficiency Drop	Longest Duration of Emission Influence	Combined Ranking
1. Second Stage Outage 8/26/75	1. Drop in boiler load - wet coal 12/8/74	1. Second Stage Outage 8/26/75
2. Second Stage Outage 12/16/74	1. Boiler Feed Problem - Wet Coal 12/20/74	1. Drop in boiler load - wet coal 12/8/74
3. Drop in boiler load - wet coal 12/8/74	3. Second Stage outage 8/26/75	3. Second Stage Outage 12/16/74
4. Centrifuge Repair 11/15/74	4. Centrifuge Repair 11/15/74	4. Centrifuge Repair 11/15/74
5. Coal Feeder Problem 12/17/74	5. Second Stage Outage 12/16/74	5. Boiler Feed Problem -Wet Coal 12/20/74
6. First Stage Outage 12/7/74	5. First Stage Outage 12/7/74	6. Coal Feeder Problem 12/17/74
7. Boiler Feed Problem Wet Coal 12/20/74	5. Coal Feeder Problem 12/17/74	7. First Stage Outage 12/7/74

* Excluded from the table is the transient condition that positively affected scrubber performance - the rising boiler load, and those that demonstrated negligible effects; The two brief centrifuge diversions; the leak of the first stage discharge header before its repair; the coal feeder problem on 1/12/75; and the second stage outage of 8/26/75, when inadequate data prohibited a proper assessment of its consequences.

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 11 November 74 Time Span 0100-0245 Transient Condition Shut Down - Leaks

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0100		5.1	--	6.5	1000		
0115						220	78.0
0130		5.1			1000		
0145				6.0		220	78.0
0200		1.0	--		1175		
0215						250	78.7
0230		0.0		5.6	1200		
0245						1200	0.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 12 November 74 Time Span 1900-2000 Transient Condition Shut down - broken belt on Dryer

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1900	188		--	7.1		185	
1915					920		80.2
1930						150	
1945					900		83.3
2000	185			7.0		OFF SCALE	

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 15 November 74 Time Span 0940-1300 Transient Condition Centrifuge Repair

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0930					780		
0945						100	87.2
1000	180	5.8	--	6.4	1150		
1015						250	78.3
1030					1450		
1045						340	76.6
1100		3.0	--	7.3	1300		
1115						340	73.8
1130					1200		
1145						270	77.5
1200	178	3.0	--	7.1	1100		
1215						265	75.9
1230					1050		
1245						210	80.0
1300		5.0	--	7.3	1050		

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 16 November 74 Time Span 1930-2145 Transient Condition Shut Down - leaks

Time	Boiler Load (MW)	Scrubber ΔP 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1930					1000		
1945						230	77.0
2000	178	1.2	--	7.4	1000		
2015						250	75.0
2030					1000		
2045						210	79.0
2100				7.4	1000		
2115						210	79.0
2135		0.0	--		1000		
2145						1000	0.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 24 November 74 Time Span 0240-0430 Transient Condition Start-Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0240						170	78.8
0300	148	0.5		7.7	800		
0315		2.5				150	82.4
0330					850		
0345						150	82.9
0400	150	2.5		7.7	875		
0415						240	72.6
0430		2.5			875		

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 24 November 74 Time Span 0730-0845 Transient Condition Shut-Down

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0730		4.9			900		
0745		6.8				190	78.9
0800	147	5.5		7.3	900		
0815		6.4				190	78.9
0830		0.0			850		
0845						850	0.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 1 December 7 4 Time Span 1800-2200 Transient Condition Scrubber Shut Down- Dryer Conveyor Failure

Time	Boiler Load (MW)	Scrubber △ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1800	178	6.2	--	7.1			
1810						200	
1820					900		
1830						205	77.2
1840					900		
1850						200	77.8
1900	176	-	--	-	900		
1910						200	77.8
1920					880		
1930						210	76.1
1940					850		
1950						210	76.5
2000	177	5.4	--	7.1	900		
2010						220	75.6
2020					850		
2030						210	75.3
2040					880		
2050						220	75.0
2100	183	-	--	-	< 100		
						> 500	Blow back from stack gas back pressure

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 7 December 74 Time Span 1120-1400 Transient Condition Scrubber First Stage Outage (1200-1250)

Time	Boiler Load (MW)	Scrubber △ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	THR*
1120			135,700		800			
1140						200	75.0	
1200	179	3.0	140,800	7.5	750			83.15
1220						270	64.0	
1240					780			
1300	179	5.0	146,400	7.4		220	71.8	
1400	179	7.5	173,100	7.3	875	120	86.3	

*THR = Theoretical Removal Efficiency calculated from Chemico Efficiency Equation.

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 7 December 74 Time Span 1630-1900 Transient Condition Scrubber Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
Start Up							
1630							
1640					900		
1650						270	70.0%
1700	165	0.8	188,400	7.1	900		
1710						210	76.7
1720					900		
1730						210	76.7
1740					860		
1750						205	76.1
1800	167	0.8	188,400	7.1	950		
1810						210	77.9
1820					930		
1830						205	78.0
1840					930		
1850						205	78.0
1900	173	2.8	188,400	7.2	940		

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 8 December 74 Time Span 0600-2400 Transient Condition Dropping Load Because of Wet Coal

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0600	180	8.5	188,400	7.0	1000	135	86.5
0700	179	8.5	188,400	6.9	950	140	85.3
0800	177	8.5	188,400	6.8	1000	180	82.0
0900	146	8.3	188,400	6.7	1200	200	83.3
1000	144	8.1	180,200	6.9	1100	200	81.8
1100	143	8.1	180,200	6.9	1200	200	83.3
1200	137	7.3	173,100	6.9	1100	220	80.0
1300	127	6.0	165,900	6.9	1200	240	80.0
1400	110	6.2	165,900	6.9	1100	220	80.0
1500	110	3.5	146,400	6.9	1100	240	78.2
1600	106	3.5	146,400	7.2	1050	250	76.2
1700	102	3.8	153,600	7.0	1050	250	76.2
1800	103	5.6	153,600	7.0	1020	260	74.5
1900	96	3.8	180,200	7.0	1020	260	74.5
2000	97	3.9	188,400	7.1	1020	270	81.4
2100	102	3.9	188,400	7.1	1100	280	74.5
2200	102	3.5	188,400	7.2	1000	240	76.0
2300	100	3.8	188,400	7.2	1050	280	73.3
2400	102	4.0	188,400	7.0	1100	290	73.6

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 9 December 74 Time Span 0700-1200 Transient Condition Rising Boiler Load

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0700	100	4.4	188,400	7.1	1200	320	73.3
0800	99	4.3	188,400	7.1	1050	220	79.0
0900	161	4.5	197,600	7.1	1100	230	79.1
1000	185	4.5	197,600	7.0	900	220	75.5
1100	185	4.3	197,600	6.9	850	185	78.2
1200	185	4.7	218,100	6.9	850	175	79.4

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 11 December 74 Time Span 0400-0500 Transient Condition Scrubber Shut Down- Leak in Bleed Line

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0400	163	1.0	180,200	7.2	1100	240	78.2
0425	Scrubber Down						
0500	163	0.0	180,200	7.1	1100	>1000	Back flow due to stack gas back pressure

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 13 December 74 Time Span 1810-2200 Transient Condition Scrubber Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1810	120	1.4	228,400	7.2	1250		
1855						240	80.8%
1900	118	3.2	228,400	7.2			77.2
1910					1150		
1920						285	75.2
2000	111	2.7	242,200	7.1	1180	290	75.4
2100	116	2.7	228,400	7.1	1200	275	77.0
2200	113	5.3	242,200	6.8	1250	235	81.2

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 14 December 74 Time Span 1400-1500 Transient Condition Variance of Liquid Flow Rates

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1400	146	6.2	159,700	6.9	1150	205	82.2
1415	-	6.4		6.9	1140	200	82.5
1430	-	6.4		6.9	1140	200	82.5
1500	-	6.0	153,600	7.0	1190	195	83.6

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 16 December 74 Time Span 1300-1700 Transient Condition Scrubber 2nd stage down & start up; wet coal

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	O_2 % In	O_2 % Out
1200	146	6.4	159,700		940	160	83.0		
1300	146	0.0		7.5					
1310						685			
1322					890				
1343						685	23.0		
1352					885				
1400	146	0.0	74,800	> 8					
1412						680	23.6		
1424					890				
1439						790	20.0		
1457					900				
1500	143	0.0	82,900	>8	900				
1510	Scrubber Start Up (2nd Stage)					135	85.0		
1515	135	(1.0) Assumed				115	87.2		
1520	135					115	87.2		
1530	110				600			10.0+	
1540	78				450	100	77.8		10.+
1550	110					110	75.6		9.0
1555	165	1.8		7.5		80	82.2		10.+

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 17 December 74 Time Span 0900-1400 Transient Condition Experiements changing the liquid flow rate in the scrubber 2nd stage

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Liquid Flow Rate*
0900	151	3.7	130,600	7.2	790	165	79.1	
0950		8.2		7.1	1050	170	83.8	5900
1000	162	8.2	159,700	7.1	1050	170	83.8	
1035		8.0		7.0	1020	135	86.8	7000
1100	174	8.7	159,700	7.0	950	135	85.8	6800
1130		7.4		7.0	900	170	81.1	5100
1150		6.2		7.0	850	195	77.1	4000
1200	182	6.0	180,200	7.1	960	180	81.3	
1225		6.6		7.2	880	180	79.5	5100
1245		8.3		7.3	810	120	85.2	5000
1300	182	8.5	197,600	7.1	810	135	83.3	
1320		9.5		-	805	110	86.3	5800
1400	182	9.7	180,200	7.2	790	110	86.1	5800

*Liquid Flow Rate (MgO) (gpm)

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 19 December 74 Time Span 0800-1300 Transient Condition Scrubber Second Stage Outage to repair 2nd stage recycle header

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0800	157	8.5	197,600	7.0	*1200	234	80.5
0900	157	8.4	207,400	7.0	1200	230	80.8
1000	157	-	159,700	-	1200	>300	<75.0
1100	156	-	165,900	-	1200	>300	<75.0
1200	-	-	165,900	-	1200	>300	<75.0
1300	Scrubber completely shut down.						

*Readings from DuPont Analyzer

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 19 December 74 Time Span 1600-1800 Transient Condition Scrubber Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
Start Up							
1600	-	2.8	173,100	7.0	1200	>300	<75.0
1700	150	6.0	188,400	7.1	1300	220	83.1
1800	143	6.2	197,600	7.1	1200	228	81.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 20 December 74 Time Span 0700-1200 Transient Condition Wet Coal-Boiler Feed Problems

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0700	90	3.5	99,300	7.0	1180	280	76.3
0800	99	3.4	91,100	7.0	1200	285	76.3
0900	98	3.6	99,300	7.0	1180	240	79.7
1000	94	3.6	--	7.0	1180	240	79.7
1100	88	3.6	--	7.0	1020	200	80.4
1200	90	3.8	--	7.2	960	186	80.6

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 22 December 74 Time Span 0800-1100 Transient Condition Scrubber Shut Down-Leaks Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0800	136	6.2	135,700	7.1	980	180	81.6
0900	140	-	-	-	-	-	-
Start Up							
1000	166	-	-	-	-	-	-
1100	174	6.2	200	7.2	890	128	85.6

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 22 December 74 Time Span 0800-1100 Transient Condition Scrubber Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1020	166		--				
1100	174	6.2	140,800	7.2	890	128	85.6
1200	173	6.2	140,800	7.2	800	140	82.5
1300	174	6.3	140,800	7.1	800	200	75.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 23 December 74 Time Span 0800-0900 Transient Condition Scrubber Shut Down-Leaks in first and second stage.

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0800	140	8.0	173,100	7.0	880	160	81.8
0900	169	6.2	146,400	7.2	860	160	81.4
0930	-	-	-	-	-	-	-

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 29 December 74 Time Span 1600-1800 Transient Condition Scrubber Shut Down-Leak in elbow of 1st stage

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1600	137	3.5	165,900	7.1	1680	300	82.1
1700	-	0.0	130,600	7.7	200	1600	Back flow from stack gas pressure
1800	-	-	130,600	-		-	-

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 8 January 75 Time Span 1400-1700 Transient Condition Shut Down - Leaks in 1st Stage / Start Up - 1st Stage only

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1400	181	-	120,300	8	1380	1290	6.5%
1500	DOWN FOR REPAIRS						
1600							
1700	176	1.0		8	1300	1220	6.2%

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 8 January 75 Time Span 1700-2400 Transient Condition Scrubber operating with only 1st Stage

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1700	176	1.0	180,200	8	1300	1220	6.2
1800	179	3.4	255,000	"	1320	1290	2.3
1900	179	4.0	291,800	"	1300	1290	0.8
2000	181	4.0	291,800	"	1380	1340	3.5
2100	180	4.0	291,800	"	1390	1260	9.4
2200	183	4.0	291,800	"	1390	1280	7.9
2300		4.0	291,800	"	1430	1340	6.3
2400		4.0	438,300	"	1430	1340	6.3
						AVERAGE:	5.3

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 10 January 75 Time Span 0800-0830 Transient Condition Shut Down-Repairs & Preparation 1st Stage Only

Time	Boiler Load (MW)	Scrubber ΔP 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0800	119	-	266,200	-	900	800	11.1
0830	SHUT DOWN						

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 18 January 75 Time Span 1340-1730 Transient Condition Start Up-Shut Down (1730) (1315) Screw Conveyer Overload

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1304					860		
1355						200	76.7
1410	126	5.6	197,600	7.5	810		
1425						140	82.7
1440					940		
1505	150	4.2	188,400	7.2		180	80.9
1520					900		
1530						170	81.1
1545					860		
1600	178	5.4	188,400	7.3	900		
1615						140	84.4
1630					900		
1645						120	86.7
1700					850		
1730	SHUT DOWN						

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 19 January 75 Time Span 1130-1345 Transient Condition Start Up - Shut Down (1130) (1345 1st Stage Overflow

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1130						200	
1145					1100		
1200	177	3.4	180,200	7.5		190	82.7
1215					1050		
1230						195	81.4
1245					1000		
1300	175	4.4	173,100	7.2		200	80.0
1315					1000		
1330						180	82.0
1345	SHUT DOWN						

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 23 January 75 Time Span 1445-1700 Transient Condition Start Up

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1445	START UP						
1500	181	1.8	78,800	7.7	1180		
1515						100	91.5
1535					1200		
1550						280	76.7
1605	178	2.0	74,800	7.6	1250		
1620						290	76.8
1635					1190		
1650						270	77.3
1700	176	3.2	120,300	6.9	1180		

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 27 January 75 Time Span 0600-1540 Transient Condition Start Up-High Gas Flow-Shut Down

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
0520							
0530					1100		
0545						230	79.1
0600	115	0.7	--	7.4	1100		
0615						240	78.2
0630					1000		
0645						250	75.0
0700	163	1.8	--	7.4	1000		
0715						250	75.0
0730					1000		
0745						220	78.0
0800	176	0.2	--	7.5	900		
0815					880		
0830						170	80.7
0845					850		
0900	162	13.0	309,200	7.5		80	90.6
0915					900		
0930						63	93.0
0945						50	94.4
1000	116	10.8	255,000	7.4	900		
1015						75	91.7
1030					900		
1045						90	90.0
1100	138	10.2	242,200	7.2	900		
1115						110	87.8
1130					1000		
1145						120	88.0

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 27 January 75 Time Span Continued Transient Condition Start Up-High Gas Flow-Shut Down

Time	Boiler Load (MW)	Scrubber Δ P 2nd Stage (in. H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %
1200	174	8.0	207,400	7.2	1000		
1220						120	88.0
1235					1000		
1250						120	88.0
1305	175	7.8	207,400	7.3	1000		
1320						130	87.0
1345					1000		
1400	174	8.0	228,400	7.1		120	88.0
1415					1000		
1430						115	88.5
1445					1000		
1500	173	2.2	188,400	7.2		200	80.0
1510					950		
1520						205	78.4

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 11 August 75 Time Span 1435-2200 Transient Condition Start up

Time	Boiler Load (mw)	Scrubber ΔP Second Stage ($in.H_2O$)	Scrubber Inlet ACFM	Scrubber pH	*Inlet SO_2 (ppm)	*Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
1435	185		87,000					
1800	182	2.6	218,100	7.7	900	264	70.7	
2000	183	3.4	218,100	7.3	900	264	70.7	
2200	183	3.4	218,100	7.1	900	264	70.7	

*DuPont Unit

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 15 August 75 Time Span 0200-0400 Transient Condition Complete Shut Down/ Dryer plugged

Time	Boiler Load (mw)	Scrubber Δ P Second Stage ($in.H_2O$)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
0200	178	3.8	188,400	7.2	*1080	*240	77.8	
0400	Shut Down							

*DuPont Unit

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 22 August 75 Time Span 1400-1600 Transient Condition Start up and Velocity increase (1620 FPM to 2025 FPM)

Time	Boiler Load (mw)	Scrubber Δ P Second Stage ($in.H_2O$)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
1400	176				20	1000		930
1430		Start			20	1050		1175
1438						1070		1500
1439						1070		1500
1440						1070		1560
1441						800		1430
1442						500		1375
1443						200		1375
1444						250		1375
1445					1000	300	70.0	1375
1446					1020			1430
1447					1050			1500
1448					1100			1500
1449					1100			1500
1450					1100			1500
1500			153,600			370	69	1560
1515						380	68	1560
1530						380	68	1560
1600	177	2.0	165,900	7.4	1190	360	68	1620

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 22 August 75 Time Span 1630-1800 Transient Condition Velocity increase (1620 FPM to 2025 FPM)

Time	Boiler Load (mw)	Scrubber Δ P Second Stage (in.H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
1600		2.0	165,900					
1630	177				1200	370	69	1620
1645					1200	370	69	1560
1700	179		173,100		1190	330	72.3	1760
1715					1130	330	70.8	1940
1730					1130	310	72.6	2025
1745					1150	300	74	1940
1800	184	3.2	207,400	7.3	1170	300	74.4	1940

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 23 August 75 / 24 August 75 Time Span 2100 Transient Condition Centrifuge Clog/ Complete Shut Down

Time	Boiler Load (mw)	Scrubber Δ P Second Stage ($in.H_2O$)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Hastings Voltage/ Velocity
2000	174	3.2	207,400	7.0	*1500	*360	76.0	3.3v/2025
2100	180					400	73.3	3.3v/2025
2115						400	73.3	3.3v/2025
2120						400	73.3	2.4v/1375
2125						500	66.7	2.4v/1375
2200	178	1.5	146,400	7.0	*1080	*480	55.6	2.5v/1430
2300	174		146,400			480	55.6	2.4v/1375
2315						480	55.6	1.7v/1025
2330						450	58.3	1.9v/1125
2345						470	56.5	2.1v/1225
2400	158		120,300			500	53.7	2.1v/1225
2415						550	49.1	2.3v/1325
2430						500	53.7	2.0v/1175
0100	114					480	55.6	1.9v/1125
0200	107					480	55.6	2.0v/1175
0300	104					420	61.1	2.0v/1175
0303						420	61.1	2.0v/1175
0304						420	61.1	1.6v/1025
0305	Scrubber off					420	61.1	1.2v/810
0309						1000		

*DuPont Unit

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 25 August 75 Time Span 1300-1600 Transient Condition Start Up

Time	Boiler Load (mw)	Scrubber ΔP Second Stage (in.H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
1300	184							
1330	Start Up							
1400	175	1.8	173,100	7.3	1080*	360*	66.7	
1500	178		173,100					
1600	182	3.5	180,200	7.3	1140*	300*	73.7	

*DuPont Unit

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 26 August 75 Time Span 0400-1400 Transient Condition Rapid velocity changes

Time	Boiler Load (mw)	Scrubber Δ P Second Stage (in.H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
0400	176	3.2	197,600	6.9	1300	390	70.0	1840
0415					1200	400	66.7	1175
0500	183				1200	420	65.0	1275
0515					1380	470	65.9	1560
0600	180	3.4	197,600	6.9	1320	400	69.7	1940
0700	176		125,400		1350	470	65.2	1225
0710						470	65.2	1275
0715					1300			1175
0716					1200			1275
0717					1150			1275
0718					1370			1275
0719					1350			1225
0720					1300			1275
0730						470	63.9	1225
0800	177	0.9	125,400	7.2	1340	540	59.7	1225
0815					1340	540	59.7	1275
0900	176		120,300		1350	490	63.7	1175
1000	178	0.8	120,300	7.1	1340	450	66.4	1175
1030					1290	420	67.4	1175
1045					1290	420	67.4	1430
1100	180		146,400		1250	410	67.2	1375
1200	184	1.6	146,400	7.1	1250	420	66.4	1430
1230					1250	420	66.4	1430
1245					1200	370	69.2	1690
1300	185		173,100		1200	350	70.8	1690
1330					1120	320	71.4	1940
1345					1100	300	72.7	1940
1400	185	3.6	197,600	6.8	1100	300	72.7	1940

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 26 August 75 Time Span 1850-1920 Transient Condition 2nd stage shut down

Time	Boiler Load (mw)	Scrubber Δ P Second Stage (in.H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Velocity FPM
1800	178	3.5	--	7.1	1175	350	70.2	1500
1830	Shut Down				1175	330	71.9	1500
1845					1140	320	71.9	1500
1850					1140	320	71.9	1500
1855						400	64.9	1620
1900	174		173,100			900	21.1	1690
1905					1120			1690
1910					1120			1620
1915						1000	10.7	1690
1920						1000	10.7	1690

BOILER/SCRUBBER DATA DURING TRANSIENT CONDITIONS

Date 27 August 75 Time Span 1400-1540 Transient Condition 1st Stage Shut Down

Time	Boiler Load (mw)	Scrubber Δ P Second Stage (in.H_2O)	Scrubber Inlet ACFM	Scrubber pH	Inlet SO_2 (ppm)	Outlet SO_2 (ppm)	SO_2 Removal Efficiency %	Hastings Voltage/ Velocity
1400	175		87,000		1390	1200	13.7	1.3v/350
1415					1350	1200	11.1	1.3v/850
1430					1350	1140	15.6	1.3v/850
1445					1200	1150	4.2	1.2v/810
1500	180		87,000		1275	1150	9.8	1.3v/850
1515					1275	1100	13.7	1.3v/850
1530	Shut Down				1080			1.3v/850
1535						900		1.2v/810
1536						900		1.1v/770
1537						900		1.0v/730
1538						900		0
1539						1000		0
1540						1025		0
Average							11.4	

APPENDIX F

LISTS OF SCRUBBER MALFUNCTIONS AND MAINTENANCE

LIST OF

SCRUBBER MALFUNCTIONS

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Oct. 8	Leak in 10" flange	Yes	3 hr.	Blank installed ahead of leak
Oct. 8	Centrifuge hopper clogged	No		Diverted centrifuge; wash hopper and dryer with water
Oct. 9	"A" first stage recycle pump won't start	No		Breaker repaired
Oct. 9	Leak in second stage suction header	No		Repaired on Oct. 10
Oct. 9	Centrifuge chute clogged	No		Divert centrifuge; wash chute
Oct. 9	"A" MgO pump not operating properly	No		Pump replaced during shutdown
Oct. 9	$MgSO_3$ weigh belt out of order	No		Bypass used
Oct. 10	ID fan kicked out	Yes	1 hr.	Restart fan
Oct. 10	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Oct. 11	Bucket elevator ball bearings failed	No		Divert centrifuge; lower fan amps; replace bearings
Oct. 12	"B" recycle pump and line clogged	No		Lower fan amps; wash out pump and line
Oct. 12	Leak in suction header of "C" recycle pump	No		Switch to "B" pump; leak sealed itself on "C" pump
Oct. 14	Leak in seal of "B" MgO pump	No		Repaired during Oct. 18 outage
Oct. 14	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Oct. 14	Leak in first stage discharge line at elbow	Yes	27 hrs.	Inspect and replace line with a blank
Oct. 15	Centrifuge seized	No		Bump the start switch and it broke loose

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Oct. 16	South pinch valve leaking	No		Leak plugged
Oct. 18	1. Leak in 6" blank at top of scrubber 2. Leak in gasket of 14" first stage blank 3. 6" pinch valve liner leaking 4. "A" and "B" transfer pumps leaking	Yes	*5 days 6½ hrs.	*Repairs 1 through 4 took 2 hrs. 45 mins. At start up, leaks developed in the MgO magnetic flow meter to the tangential sprays
Oct. 22	"A" dilution tank agitator not working	No		"B" tank used; oil replaced in "A" tank gear box
Oct. 23	Leak in pH meter pot	No		Leak plugged
Oct. 23	Two leaks in centrifuge case	No		One leak plugged; the other couldn't be reached
Oct. 23	Leak in "B" recycle pump	No		"C" pump put in service; re-wrap "B" pump
Oct. 24	Leak in discharge line from sump pump	No		Repaired Nov. 7
Oct. 24	Centrifuge chute clogged	No		Bypass centrifuge; unplug chute
Oct. 24	Discharge line on "A" MgO pump clogged	No		Switch to "B" pump; clean "A" pump
Oct. 25	Centrifuge hopper clogging continuously	No		Divert centrifuge; wash hopper, adjust vibrator cycle time
Oct. 25	Boiler tube leaks	Yes	15 days 21 hrs.	Repaired
Nov. 10	pH meter not working	No		Readings taken on bench pH meter
Nov. 10	Leak in centrifuge cover	Yes (Nov.11)		Repaired during next outage

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Nov. 10	Steam control valve not operating properly	No		Operate valve manually
Nov.10	Leak in mother liquor return line	No		Repaired during next outage
Nov. 11	1.Large leak in second stage bleed line 2.Leak in pH meter 3.Leak in bypass around second stage recycle pump discharge valve	Yes	2 days 18 hrs.	Repaired
Nov. 13	pH meter inaccurate	No		Readings taken on bench pH meter. Meter repaired on Nov. 15
Nov. 14	Leak in centrifuge cover	No		Repaired Nov. 15
Nov. 14	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 14	"B" thickener valve opened up causing the dilution tank to overflow	No		Valve reset
Nov. 14	MgO weigher motor not operating	No		Electrician called to repair
Nov. 15	Leak in centrifuge cover gasket	No		Repaired Nov. 18
Nov. 15	Leak in "B" thickener	No		"A" thickener put into service
Nov. 16	"A" second stage recycle pump noisy and vibrating	No		Switched to "B" pump until "A" is inspected
Nov. 16	$MgSO_3$ conveyor kicked out twice	No		Divert centrifuge; clean out restriction
Nov. 16	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 16	$MgSO_3$ weigh belt broke	No		Placed on bypass until repaired

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Nov. 16	$MgSO_3$ bucket elevator kicked out three times	No		Divert centrifuge; dig out buckets
Nov. 16	6" pinch valve liner in the first stage recycle line ruptured	Yes	2 days 20 hrs.	Repaired during shutdown
Nov. 19	Leak in centrifuge cover	No		Welded on Nov. 22
Nov. 20	Inside bearing on dryer conveyor broke	No		Repaired Nov. 22
Nov. 20	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 20	New leak in centrifuge cover	No		Welded on Nov. 22
Nov. 21	Bucket elevator tripped	No		Dig out boot
Nov. 21	Rappers on the dryer fell off	No		Replaced Nov. 22
Nov. 21	Thermocouple and conduit on dryer broken off	No		Repaired Nov. 22
Nov. 21	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 21	Belts on dryer ID fan burnt off	Yes	2 days 7 hrs.	Belts replaced in 2½ hours. The dryer ID fan would not start. During this outage the boiler burst a tube causing Unit #3 to go off line.
Nov. 24	Dryer screw conveyor hub failure	Yes	6¼ hrs.	Hub replaced
Nov. 25	$MgSO_3$ solid equipment kick out	No		Dig out buckets and dryer screw conveyor
Nov. 25	Centrifuge cover leaks	No		Welded during outage
Nov. 26	Centrifuge hopper clogged twice	No		Divert centrifuge; wash hopper
Nov. 26	Hole in 6" recycle water line on first stage	No		Temporary rubber patch applied

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Nov. 27	First stage level controller and MgO level controller not working	No		Repaired
Nov. 27	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 28	Leak in first stage distribution header	No		Hole patched temporarily
Nov. 28	Dryer clogged	No		Centrifuge diverted; dryer allowed to clean itself
Nov. 28	Drain nippel in sump pump leaking	No		
Nov. 28	pH meter out of calibration	No		Recalibrate
Nov. 29	Leak in 6" bleed line from first stage	No		Pipe clamps installed
Nov. 29	Dryer clogged	No		Divert centrifuge; allow dryer to clear
Nov. 30	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Nov. 30	Leak in 6" bleed line worse	No		Pipe clamps installed
Dec. 1	Southwest torus spray broke off	No		Flows cut back to torus sprays; unsuccessful attempt to install blind
Dec. 1	Leaks in 6" bleed line out of control	Yes	3 days 18 hrs.	Temporary replacement line installed
Dec. 5	Leak in first stage discharge header	No		Stop recycle; install blind
Dec. 7	Leak in 6" first stage recycle line at pinch valve	No		Patch leak
Dec. 7	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Dec. 8	MgO weigh feeder belt ran off track	No		Reset belt

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Dec. 8	New leak in 6" first stage recycle line	No		Patch hole
Dec. 8	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Dec. 8	Dryer clogged	No		Divert centrifuge; allow dryer to clear itself
Dec. 9	Transition pipe at screw feeds clogged	No		Divert centrifuge; clean out
Dec. 10	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Dec. 10	Centrifuge cover leak	No		
Dec. 11	Leaks in 6" first stage bleed line	Yes	32 hrs.	Replace line
Dec. 12	6" first stage bleed line sleeve failure	Yes	28 hrs.	Replace line
Dec. 13	Mother liquor agitator kicked out	No		Reset
Dec. 14	Hole in 6" pinch valve on first stage recycle line	No		
Dec. 15	Leak on second stage discharge header	No		Repaired Dec. 16
Dec. 15	Lost flow in "B" MgO pump	No		Switch to "A" pump; clean out "B" pump
Dec. 16	Lost flow in "B" MgO pump	No		Backflush pump
Dec. 16	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Dec. 17	Hole in first stage of scrubber vessel	No		Hole patched
Dec. 17	pH meter clogged with crystals	No		Flush out
Dec. 17	Leak in second stage discharge header	No		Repaired Dec. 19
Dec. 18	Dryer conveyor tripped	No		Divert centrifuge; reset switch
Dec. 18	Another leak in second stage discharge header	No		Repaired Dec. 9
Dec. 18	Dryer clogged	No		Cut back load and allow dryer to clear itself
Dec. 19	Failure of second stage discharge header pipe	Yes	2½ hrs.	Weld leak
Dec. 19	"C" MgO pump clogged	No		Unclogged Dec. 30
Dec. 19	Dryer conveyor tipped	No		Reset switch
Dec. 19	Leak in first stage scrubber vessel	No		Repaired Jan.13
Dec. 20	Leak in first stage reducer	No		Temporary patch applied; welded on Dec.21
Dec. 20	Front rappers on dryer not hitting	No		Band couldn't be tightened; centrifuge diverted until dryer cleared; repaired on Jan. 11
Dec. 20	Leak in line to upper pond	No		Replaced with hose
Dec. 21	Leaks on two of the first stage nozzle lines	No		Leaks plugged
Dec. 21	Leak in 8" pinch valve liner on first stage recycle line	Yes	1 hr. 10 min.	Scrubber shut down on Dec. 22 to repair leak
Dec. 22	Leak in first stage recycle line to plumb bob	No		Welded during Dec. 23 outage

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Dec. 23	1. Leak in 8" pinch valve on first stage recycle line 2. Leak in second stage discharge line	Yes	3 days 12 hrs. 40 min.	1. Replaced with spool piece 2. Leak welded
Dec. 26	pH meter not working	No		Remove restriction from line
Dec. 28	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Dec. 28	Leak in elbow of "A" first stage pump	No		Leak plugged
Dec. 28	Leak at pH meter electrode	No		Leak plugged
Dec. 29	Bucket elevator tripped	No		Dug out boot; reset elevator
Dec. 29	Leak in elbow of "A" first stage pump	Yes	15 min.	Leak plugged
Dec. 29	Leak in elbow of "A" first stage pump	Yes	4 days 22 3/4 hrs.	Leak required only 15 minutes to repair, but fan would not start. It was decided to leave the scrubber off so other repairs could be made.
Jan. 4	3" drain at bottom of scrubber plugged	No		Unplug during shutdown
Jan. 4	Leak in second stage drain connection	Yes	3 days 9 hrs.	Leak repaired
Jan. 8	Leak in elbow of "B" discharge pump	Yes	2 hrs.	Leak repaired
Jan. 10	Leaks in second stage lines	Yes	28 hrs.	Inspect, repair and replace lines
Jan. 11	MgO belt slipping	No		Belt tightened
Jan. 11	MgO steam sparger clogged	No		Cleaned
Jan. 11	Leak in centrifuge cover	No		

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Jan. 12	"A" MgO pump failure	No		Switch to "B" pump
Jan. 13	SO_2 analyzer outlet probe clogged	No		Stainless steel bands and tubing need to be replaced
Jan. 13	MgO weigh feeder incorrect	No		Recalibrate
Jan. 13	Another leak in centrifuge cover	No		
Jan. 14	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper; use vibrators constantly
Jan. 14	First stage level controller frozen	No		Manual control used until controls unfrozen
Jan. 14	"A" thickener underflow pump and rotometer frozen	No		Pump was cleared; rotometer to be replaced
Jan. 14	Run out of MgO	Yes	3 days 20½ hrs.	
Jan. 18	$MgSO_3$ conveyor at top of silo kicked out	Yes*		*Unable to inspect or fix due to icy conditions on platforms. Conveyor freed when conditions permitted.
Jan. 19	Leak in liner of first stage bleed valve	No		Removed metal pieces from valve; no replacement liner available.
Jan. 19	Oil leaking from mother liquor agitator gear box	No		Refilled with oil
Jan. 19	First stage overflow	Yes	4 days 45 min.	Remove restriction from first stage bleed line
Jan. 23	First stage bleed lines semi restricted	No		Both thickeners put in operation to get more flow to the dilution tank
Jan. 23	MgO weigh feeder belt slipping	No		Cut back fan amps so MgO could catch up

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Jan. 24	Leak in first stage tangential spray header	No		Patched during boiler outage
Jan. 24	Leak in first stage torus spray	No		Patched during boiler outage
Jan. 24	Centrifuge hopper clogged	No		Divert centrifuge; wash hopper
Jan. 24	Bucket elevator tripped	No		V-Belts on top of elevator replaced
Jan. 24	Leak in 10" header at top of scrubber	No		Patch leak
Jan. 25	Leak in 10" header at top of scrubber	Yes*	38½ hrs.	*Shut down to patch leak and to save wear on the system as visitors are expected on Jan. 27
Jan. 27	Inlet damper for Mode II would not open	No		Damper opened with aid of a crow-bar.
Jan. 27	Restriction in first stage pump "A"	No*		*Shut down shortly after. Restriction was a broken off tangential nozzle. Scrubber to be kept off until after a scheduled boiler outage.
Aug. 11	First stage bleed valve liner failure	No		Replaced Aug. 12
Aug. 11	Cracked steam control valve	No		Replaced with spool piece on Aug. 14
Aug. 15	Dryer Clogging	Yes	7 days 10½ hrs.	Clean dryer manually
Aug. 24	Dryer Clogging	No		Remove build up manually
Aug. 24	Bucket elevator tripped	No		Reset elevator
Aug. 24	Excessive centrifuge vibration	Yes	37½ hrs.	Repairs made to centrifuge
Aug. 26	Wet centrifuge cake	Yes*		*First stage only; weir height on centrifuge lowered

Date	Type of Malfunction	Shut-down Required	Duration of Outage	Remedial Action Taken
Aug. 27	Leak in first stage recycle lines	Yes	14 days 4½ hrs.	Replace lines
Sept. 19	Gear box failure in "A" thickener	No		"B" thickener only used
Oct. 20	Pins sheared in centrifuge	Yes	Final	None

LIST OF

SCRUBBER MAINTENANCE

Oct. 9

1. "A" underflow booster pump installed

Oct. 11

1. Inboard bucket elevator bearing to be greased once per day.
2. Outboard bucket elevator bearings to be greased once per week.
3. Silo vibrator motors to be greased once every three months.
4. All unused pumps and the centrifuge (when not in use) shall be bumped at least once per day.

Oct. 15

1. Silo vibrator motor replaced.

Oct. 18 to Oct. 21

1. Inspect MgO slurry flow meter.

Oct. 22

1. Boulders of MgO broken up in silo.

Oct. 25

1. Electricians adjust vibrator times; install toggle switches for manual operation.

Oct. 27

1. A detailed inspection/lubrication program was initiated by Chemico personnel to be performed during the 4-12 shift. The program consisted of inspecting/lubricating the following:

Thickener Area -

1. Transfer pump bearing pedestals
2. Underflow pump bearing cases.
3. Underflow booster bearing cases.
4. Dilution tank gear reducer-agitator.
5. Dilution tank agitator bearings.
6. Thickener rake drive gears.
7. Thickener rake lift gears.
8. Dryer

    A. Lubricate tires
    B. Lubricate trunions
    C. Lubricate thrust bearings
    D. Oil drive gear case

Scrubber Area -

1. ID fan motor oil levels
2. ID fan fluid drive oil levels
3. ID fan bearings oil
4. ID fan boiley controllers
5. First stage pumps-motors oil level
6. First stage pumps-bearings oil level
7. Second stage pumps-bearings oil level
8. Dryer ID fan-bearings lubricate
9. Dryer ID fan-bailey controller lubricate
10. #4 conveyor (top silo) bearings and reducer
11. Bucket elevator bearings and reducer
12. Plumb bob limitorque gear reducer

Dryer Area -

1. #1 conveyor bearings and gear reducer
2. #2 conveyor bearings and gear reducer
3. Dryer conveyor bearings and gear reducer
4. Centrifuge reservoir and bearings
5. Stack damper (dryer) lubricate
6. Premix tank agitator bearing lubricate
7. MgO mix tank agitator gear reducer
8. Mother Liquor tank agitator gear reducer
9. MgO pumps bearing oil
10. Mother Liquor pumps bearing oil
11. Bottom bucket elevator four bearings (weekly)

Oct. 27 to Nov. 11

1. Clean out valves on "A" MgO pump dicharge line installed.
2. The level in the MgO silo was measured.
3. The ID fan was inspected.
4. Dryer rappers were adjusted.
5. Rappers on the centrifuge hopper were relocated.
6. A new motor was installed on the dryer conveyor.
7. Vibrator installed on the $MgSO_3$ silo so sticking would not occur.
8. First stage cone was opened and inspected.
9. Bucket elevator bearings were inspected and lubricated; one was replaced.
10. Weigh belts were zeroed and calibrated.
11. Electricians installed a larger heater in the "B" MgO pump switch.

Nov. 11 to Nov. 13	1.	Temperature monitors on fire box and steam control valves were serviced.
	2.	The thermocouple on the circulation line was repositioned for more effective control.
	3.	Flow rate checks on the MgO slurry lines.
Nov. 18 to Nov. 19	1.	Hub on the dryer screw conveyor was inspected and replaced.
	2.	The liner on the centrifuge divert valve was inspected and replaced.
Nov. 22	1.	Electrician removed the inspection plate from the dryer. ID fan wouldn't start and discovered the housing one-half filled with water. After draining the housing, the pulley hub was inspected and found to be worn.
	2.	Inspected bearings on dryer screw conveyor.
Nov. 25	1.	pH controller serviced.
Dec. 3 to Dec. 5	1.	Removed one stellited restricting orifice plate from the first stage bleed line to the thickener.
Dec. 6	1.	Removed the three remaining stellited restricting orifice plates from the first stage bleed line.
	2.	DuPont SO_2 analyzer serviced.
Dec. 9	1.	Oilers on vibrators serviced.
Dec. 10	1.	Overload heaters installed in "B" MgO pump.
Dec. 12	1.	"A" thickener rakes were inspected.
Dec. 13	1.	Inspected first stage bleed line for restrictions.
Dec. 14	1.	Removed and inspected motor on Mother Liquor agitator; gears need replacement.
Dec. 16	1.	Larger overload heaters installed in "B" second stage pump.
Dec. 17	1.	Blanks were installed in the tangential nozzle lines to prevent leaks.
Dec. 23 to Dec. 26	1.	Inspected screens in the MgO tank.
	2.	Pre-mix tank cleaned.

Dec. 27	1.	Pipe thickness measurements made.
	2.	Adjusted packing on first stage and transfer pumps.
Dec. 29 to Jan. 3	1.	Inside of the second stage vessel inspected.
	2.	Drain valves installed on the casings of "B" and "C" MgO pumps.
	3.	Top mist eliminator washed.
Jan. 6 to Jan. 7	1.	Second stage vessel checked for leaks.
Jan. 10	1.	During the past week, all equipment requiring lubrication was serviced.
Jan. 15 to Jan. 18	1.	Repacked both first stage recycle pumps.
	2.	Calibrate level controllers.
	3.	New buckets installed on $MgSO_3$ elevator.
	4.	Rotometers thawed and insulated as needed.
	5.	Clean out MgO pre-mix tank.
	6.	Inspect, clean and grease steam sparger valve.
	7.	Cleaned guages on MgO pumps.
	8.	pH meter pot serviced.
	9.	"B" first stage pump taken apart to remove an 18" section of tangential nozzle.
	10.	Inspected tangential nozzles; 6 of 10 missing.
Jan. 19 to Jan. 23	1.	Removed two of the remaining four tangential spray nozzles from the first stage.
	2.	All pumps fully opened to prevent freezing.
	3.	First stage discharge header drained to prevent freezing.
Jan. 25	1.	First stage recycle pumps jumpered so they could be stopped without tripping the ID fan.
Jan. 26	1.	New V-belts installed at the top of the $MgSO_3$ bucket elevator.
Aug. 24	1.	Inspection of inside of first stage vessel.
Sept. 19	1.	Inspect bucket elevator and tighten buckets if needed.

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES IERL-RTP project officer for this report is C.J. Chatlynne, Mail Drop 61, 919/541-2915.

16. ABSTRACT The report gives results of a field measurement program to determine the operability and reliability of the Chemico magnesium oxide venturi scrubber operating at Potomac Electric Power Company's Dickerson Generating Station, Frederick , MD. A continuous source-monitoring station was installed at the scrubber, complemented by a field analytical laboratory intended for the measurement and analysis of various process streams. These facilities continuously monitored process and emission variables between October 1974 and January 1975, and during August 1975. Scrubber operation was evaluated during steady-state and transient operation, the latter including startups, shutdowns, and malfunctions. During the tests, the scrubber was available about 48% of the time, including all levels of operation. Approximately 80% of system availability was steady-state, with the system operating normally. The tests showed that, although scrubber availability was not ideal (due to logistics problems in supplying raw materials (MgO), and to mechanical problems mainly attributable to under-design in such areas as piping, slurry pumps, and other auxiliary equipment), the basic scrubber concent and design should meet critical criteria once these problems are remedied.

17. KEY WORDS AND DOCUMENT ANALYSIS

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