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Babcock & Wilcox

EQUIMOLAR NO-NO_2 ABSORPTION INTO MAGNESIA SLURRY--A PILOT FEASIBILITY STUDY

RESEARCH AND DEVELOPMENT DIVISION
ALLIANCE RESEARCH CENTER

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ORDER 4193-01

RESEARCH CENTER REPORT 4653

BY: W. DOWNS

NOVEMBER 29, 1971

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EQUIMOLAR NO-NO_2 ABSORPTION INTO MAGNESIA SLURRY— A PILOT FEASIBILITY STUDY

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ABSTRACT

Purpose

The purpose of this project was to investigate the feasibility of absorption of equimolar concentrations of NO_X into MgO slurry on a 1500 cfm wet scrubbing pilot plant.

Summary

A wet scrubbing pilot plant consisting of several scrubbers was modified by the inclusion of an additional scrubber to enable series scrubbing of fly ash, sulfur dioxide, and finally nitrogen oxides. Gaseous nitrogen dioxide was injected into the flue gas following the SO_2 scrubber but before the NO_X scrubber. Seventeen tests were performed to evaluate parameters including the liquid-to-gas ratio, the ratio of NO_2 to NO, slurry concentration, stoichiometry, and gas flow rate.

Results

NO_X absorption was very poor for all conditions tested. The absorption is estimated to be less than 10%. The results are obscured by large variance in the NO_X measuring techniques. SO_2 absorption in the NO_X scrubber was dependent upon the liquid-to-gas ratio and varied from 86% to 98.3%. Deposition on the underside of the first tray of the SO_2 scrubber was observed.

Conclusions

NO_X absorption with equimolar concentrations of NO and NO_2 into MgO slurry is not feasible in the apparatus tested. It is probably unfeasible in any practical gas-slurry contacting apparatus.

NO_X absorption into soluble alkalis may be feasible and would best be done in packed towers.

Recommendations

MgO slurry should be removed from those bases being considered for aqueous NO_X absorption.

Work should continue on the feasibility evaluation of soluble bases for this system.

Research Center Report 4653
Order 4193-01
November 29, 1971
Equimolar NO_X-MgO Absorption
Project Sponsored by Environmental Protection Agency

TABLE OF CONTENTS

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

NO_x removal from power plant effluents by wet scrubbing is one of the approaches being considered by the Office of Research and Monitoring (ORM) of the Environmental Protection Agency (EPA) in its overall NO_x program. In response to the suggestion from several sources including the recommendation submitted to ORM by The Babcock & Wilcox Company under Contract CPA-22-69-162, the feasibility of absorbing equimolar concentrations of NO and NO_2 into magnesia slurry was undertaken. This work is the outgrowth of a study of wet scrubbing of pulverized coal generated flue gas for the purpose of removing particulate matter and sulfur dioxide in a 1500 cfm pilot plant. As part of that study it was shown to be unfeasible to absorb equimolar NO_x and SO_2 simultaneously. However, it was suggested that possible nitrogen oxides could be absorbed into magnesia in the scrubber following the SO_2 scrubber. This report presents the results of that work under Contract 68-02-0022.

2.0 PILOT PLANT EQUIPMENT

The pilot plant equipment used for these tests is a self-contained facility which includes coal preparation equipment, a coal-fired furnace, and a wet scrubbing pilot plant. Most of this equipment has been previously described.[1] Only the modifications and additions will be discussed in detail. A pictorial drawing of the pilot facility is shown in Figure 2.1.

2.1 COAL PREPARATION

Coal preparation involves transporting 1/2" mesh coal from the storage bunker to the pulverizer, pulverizing the coal, and transporting it to a storage hopper at the pilot plant. From there the coal is removed by a screw and conveyed to the furnace by the primary air.

The storage bunker is used primarily to supply the heating plant for the Research Center. The pulverizer used during this test program differs from the used on previous tests.[2] A Schutz-O'Neill Air Swept pulverizer Model 22-WJ superfine pulverizer was installed in early 1971 and was used exclusively for these tests.

2.2 BURNER AND FURNACE

The pulverized coal burner is a B&W cell-type circular burner with a natural gas lighter. This lighter is operated continuously during coal firing to help maintain stable ignition.

The furnace, Figure 2.2, consists of a horizontal cylinder 8 feet in length by 4-1/2 feet in diameter. This forms the actual combustion chamber. The walls of the furnace are formed by a water jacket, which dissipates heat by the production of nonpressurized steam. The inside walls are not covered with refractory.

To maintain stable ignition, the pulverized coal must be fired with preheated air. This air is supplied by a forced draft fan and preheated by two gas-fired air heaters capable of heating 10,000 lb/hr air to a temperature of 1000°F. The heat release of the furnace averages about six million Btu/hr.

Combustion gases pass from the furnace proper through three tube banks that cool the flue gas to approximately 450°F. All tubes are 1-1/2-inch O.D. on 2-1/2-inch centers with exception of the first six rows of tubes which are on 5-inch centers. Behind each tube bank is a duct permitting flue gas recirculation to the burner. See Figure 2.2. This feature, however, was not used during the tests. Flue gas leaving the tube bank passes through a transition piece to a 15-inch-diameter vertical stack. Gas flow to the scrubbing system is taken from the side of this stack. The vertical stack ends at a relief valve. The relief valve is pneumatically operated and is automatically activated during a test if furnace pressure becomes too great. The relief valve can also be operated manually from the control panel and is used during startup and shutdown operations.

The furnace control panel is fully equipped to monitor and control the furnace pressures. A 12-point Speedomax recorder provides a continuous check of the temperatures within the furnace and ancillary components. Oxygen concentration of the flue gas is continuously monitored by a Bailey O_2 Analyzer Model A57.

Located on top of the furnace (Figure 2.2) is the steam drum, a steel cylinder 4-foot diameter by 6-foot long. This drum supplies water to the furnace water jacket and acts as a steam-water separator for venting the steam to atmosphere.

2.3 FUEL

Two fuels were used cocurrently during the tests, pulverized coal and natural gas. Pulverized coal was the main fuel while natural gas was used in the lighter and accounted for about 4% (thermal) of the fuel used. A number of coal analyses were run and the results reported in Table 2.1. A typical natural gas analysis obtained from the Ohio Fuel Company is also shown in Table 2.1.

2.4 WET SCRUBBING APPARATUS

2.4.1 Particulate Scrubbing System

Flue gas leaving the furnace passed through the water tube section to the particulate venturi and cyclone, see Figures 2.3 and 2.4. As the gas entered the venturi throat, its velocity was greatly increased. It is here that the fly ash slurry spray was introduced, just slightly ahead of the throat. The fly ash particles traveling at high velocity impacted upon the slower moving slurry droplets.

The fly ash slurry was separated from the flue gas in the cyclone separator. The flue gas and slurry entered the cyclone tangentially, spinning the slurry to the walls while the gases moved toward the center and out the top. The slurry moved from the cyclone into the sump located immediately below.

The slurry was pumped from the sump and recirculated back to the venturi spray nozzle. To maintain the desired composition, part of the slurry was discarded. Fresh water previously treated by a zeolite bed was added directly to the sump and through the pump seal. Approximately 25 gal/min of slurry were recirculated through the spray nozzle, and about 9 lb/min were discarded as particulate product.

The particulate venturi spray nozzle flow was controlled by the pump and pinch valve. A pneumatically controlled pinch valve (Red Valve Company) regulated the amount of "short circuit" recirculation through the pump and valve loop. Closing the pinch valve forced more slurry through the spray nozzle. This arrangement was used instead of the normal control method via a gate or glove valve, because solids tend to collect behind the seat, thereby restricting flow. The product flow rate was controlled by an overflow weir in the sump which dumped slurry into a 55-gallon drum.

At the gas outlet from the particulate cyclone, the vortex spin was eliminated by a flow straightener. This cross-shaped member 10 inches long by 10 inches in diameter was placed in the cyclone gas exit duct.

A gas sampling probe used for both NO_X sampling and SO_2 sampling is positioned 4 inches downstream from the dust sampling connection. The probe includes a 6-inch long 1-3/4-inch pipe welded flush to the duct wall and a 1/8-inch glass tube located concentrically in this pipe. The pipe provides a "quiescent" zone in which the gas flow to the glass probe is relatively slow. This minimizes the possibility of slurry carryover from the cyclone entering into the glass tubing which in turn could result in SO_2 and NO_X sampling errors due to scrubbing of the gas by the slurry in the probe.

2.4.2 Floating Bed Absorber

The floating bed absorber (hereafter referred to as the FBA) includes a sump, two contact stages, and a liquid disengagement section. The FBA is depicted in Figures 2.5 and 2.6. This countercurrent device admits the flue gas through the sump. Ancillary components of the FBA sump include the following: a liquid level controller, sump observation window, and level indicator.

Above the sump the FBA consists of two stages. Each tray has an effective flow area of 2 square feet and consists of a 1/8-inch thick stainless steel plate perforated with 3/8-inch-diameter holes on staggered 1/2-inch centers. Each stage is packed with 6 to 8 inches of "wiffle balls."

The spray nozzle located above the top tray directs the spray of absorbing slurry onto the top tray. Since the gas rises countercurrent through the slurry, it comes into intimate contact with the absorbing slurry. Gas leaving the top tray flows through an angle iron baffle section which serves to trap large water drops, then through a York Demister to ensure that all remaining droplets are removed. The Demister is located at the very top of the FBA and consists of about 6 inches of Teflon mesh fibers. See Figure 2.7.

Flow to the spray nozzle is controlled by the aforementioned pinch valve arrangement, and the slurry composition in the sump is controlled by the product flow rate and MgO makeup rates.

2.5 INDUCED DRAFT FAN SECTION

The cleansed flue gas leaving the FBA passes downward through a vertical length containing an orifice meter, a gas sampling probe, and a particulate sampling port with slide valve. The vertical duct ends at a blank flange. Approximately 3 feet up from the flange is the takeoff for the induced draft fan. The purpose of this length of pipe is to trap any large liquid or solid particles before the gas enters the I.D. fan. A pneumatically operated damper was located at the fan inlet.

2.6 NO_X SCRUBBER AND COMPONENTS

2.6.1 NO_2 Injection System

The flue gas leaving the I.D. fan contained only small concentrations of fly ash and SO_2. However, the nitric oxide concentration (NO) was still at the same level as in the furnace exhaust gases. The flue gas left the I.D. fan through a horizontal 10-inch stainless steel (316) duct to the NO_X scrubber. At a distance of 6 feet from the I.D. fan, gaseous NO_2 was injected into the duct through a multi-orificed dispersion tube. The purpose behind the dispersion tube design was to disperse the gases as rapidly as possible to minimize the probability of extraneous reactions occurring with the momentarily concentrated NO_2 gas as it left the orifices of the dispersion tube. The NO_2 injection system is shown schematically in Figure 2.8 and consists of bottled liquid NO_2 provided with an eductor tube so that the NO_2 could be withdrawn as a liquid, a rotometer to monitor the liquid NO_2, a steam-heated boiler to vaporize the NO_2, and the dispersion tube. Placed immediately after the dispersion tube, a

6-1/2-inch inside diameter orifice was placed for the dual purpose of monitoring the total flue gas flow and to act as a means for mixing the NO_2 with the flue gas prior to entry into the NO_X scrubber.

The boiling point for NO_2 is 70°F. Thus, the tendency to form gas bubbles in the line ahead of the rotometer was an operating problem. This problem was solved by packing the valve at the NO_2 bottle in ice thereby substantially sub-cooling the NO_2.

2.6.2 <u>NO_X Scrubber</u>

The NO_X scrubber was placed approximately 12 feet from the I.D. fan. A dimensional drawing of the scrubber is shown in Figure 2.9. The basic criteria for the design and location of this scrubber are as follows:

1. Provide maximum practical gas contact time.
2. Sufficient mass transfer surface area to maximize the probability that the system would be chemical reaction rate controlling.
3. Open gas flow path.
4. Locate sufficiently far from the NO_2 injection point to provide good mixing before entry into the scrubber.
5. Locate out-of-doors as a safety precaution.

The scrubber was designed for a total gas contact time of approximately two seconds. This is about three times the maximum gas contact time employed in the FBA. If the process still proves to be chemical reaction rate controlling, then it shall be deemed as being commercially unfeasible.

The mass transfer area consisted of parallel fiber glass window screens which were irrigated with MgO slurry by four Spraying Systems 2H560WSQ stainless steel square-pattern spray nozzles. A screen material was selected because of its superior wetting characteristics. The parallel arrangement provides for an open free flow path for the gas.

Locating the scrubber out-of-doors helped insure that no personnel in the test building would inadvertently be exposed to noxious levels of NO_2 which might leak from the slightly pressurized scrubber. Views of the scrubber, both internal and overall are shown in Figures 2.10 and 2.11.

2.7 OVERALL PILOT PLANT SCHEMATIC

Figure 2.12 shows in schematic form the overall arrangement and the approximate nominal flow rates of the various streams.

TABLE 2.1. FUEL ANALYSIS

PULVERIZED COAL ANALYSES

Lab. Serial No.	C-13425	C-13426	C-13427
Sample Description	Coal from BCTU Hopper 3-9-70 2200 hrs.	Coal from BCTU Hopper 3-10-70 1000 hrs.	Coal
Ash (Dry) %	9.6	9.2	--
Sulphur (Dry) %	3.8	4.1	4.5
Carbon (Ult.)%	--	--	--

Lab. Serial No.	C-13260	C-13386	C-13377
Sample Description	Pulv. Coal Sample N. Industry Strip	Pulverized Coal Ohio Seam #5&6	Pulverized Coal Ohio Seam #5&6
Total Moisture, %	3.0	4.2	
Ash, %	8.1	--	7.4
Sulphur, %	4.1	3.8	3.7
Btu per lb. (Dry)	12730	12700	
Btu per lb. (M&A Free)	13850		

NATURAL GAS ANALYSES

Sulphur Compounds	
Hydrogen Sulfide, gr/100 cf	0.017
H_2S Sulphur Equiv., gr/100 cf	0.018
Mercaptans - S - Equiv.	0.007
Sulfide Sulphur, gr/100 cf	0.007
Residual Sulphur, gr/100 cf	0.004
Total Sulphur, gr/100 cf	0.034

	Tennessee Guernsey
Date of Sample	2/12/69
Components:	Mol %
Nitrogen	0.44
Carbon Dioxide	0.65
Methane	95.40
Ethane	2.86
Propane	0.49
Iso-Butane	0.07
N-Butane	0.06
Iso-Pentane	0.02
N-Pentane	0.01
Total	100.00

FIGURE 2.1. MAGNESIA BASE SLURRY SCRUBBING PILOT PLANT

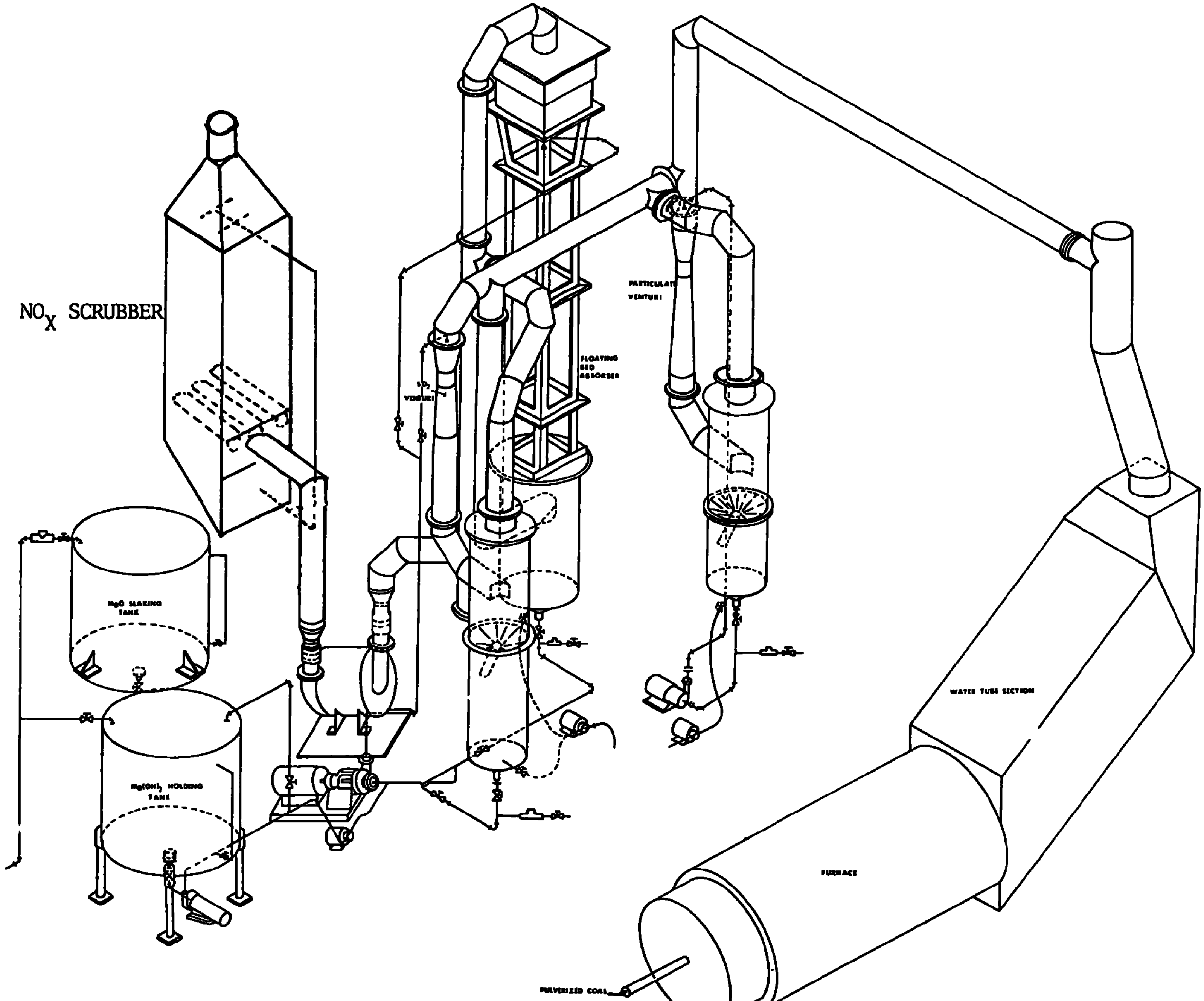


FIGURE 2.2. BASIC COMBUSTION TEST FURNACE

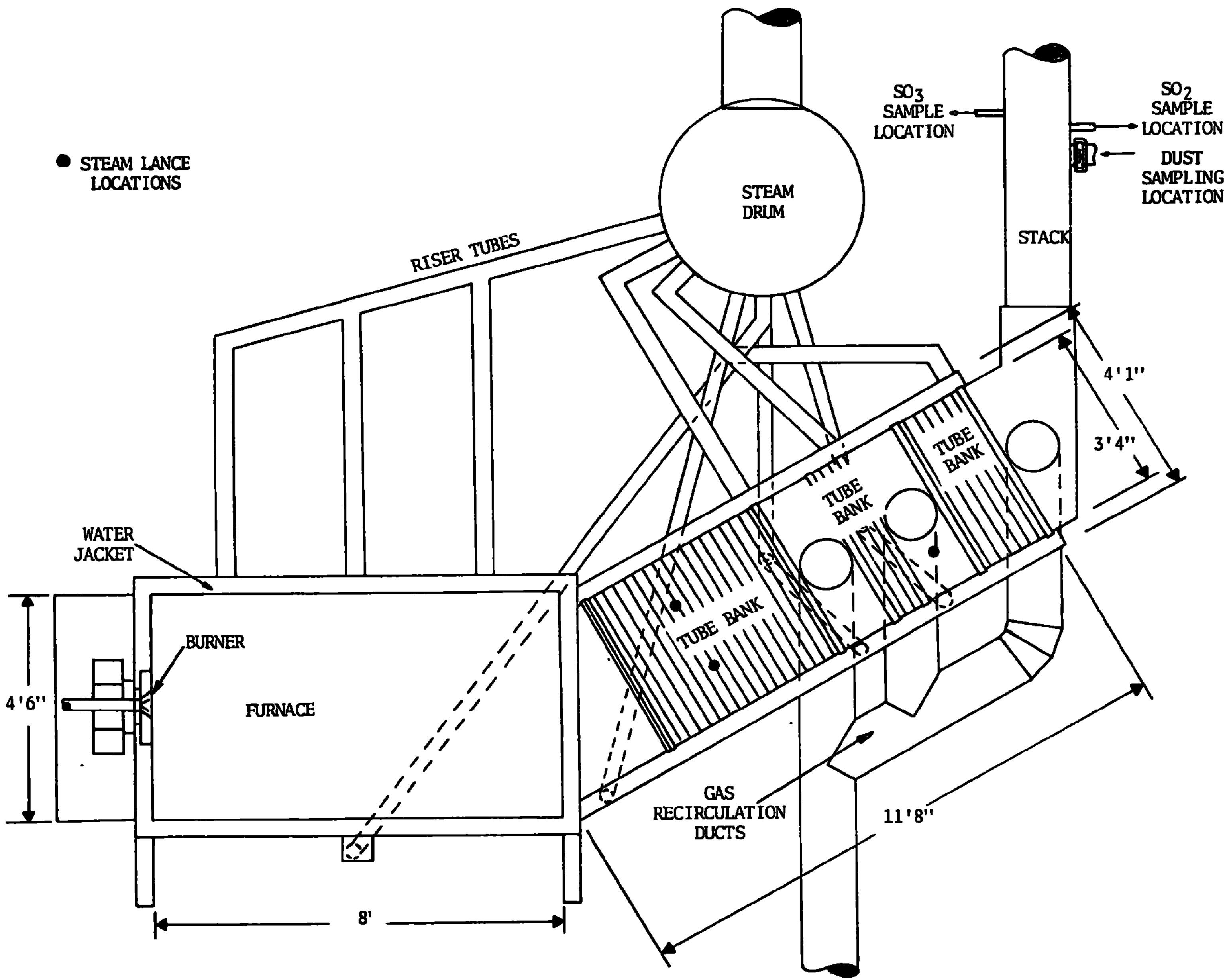


FIGURE 2.3. PARTICULATE SCRUBBING SYSTEM

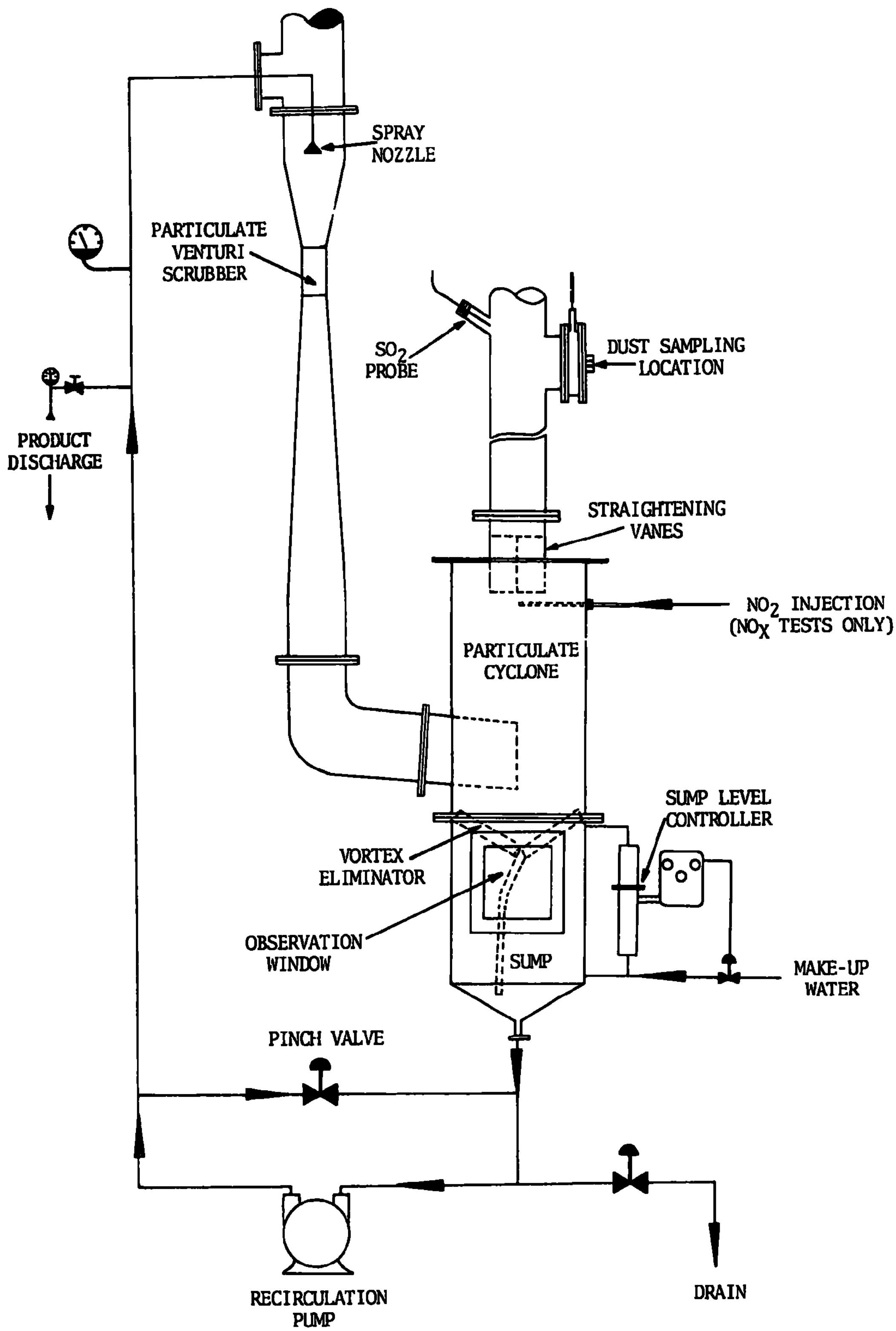


FIGURE 2.4. PARTICULATE SCRUBBING SYSTEM

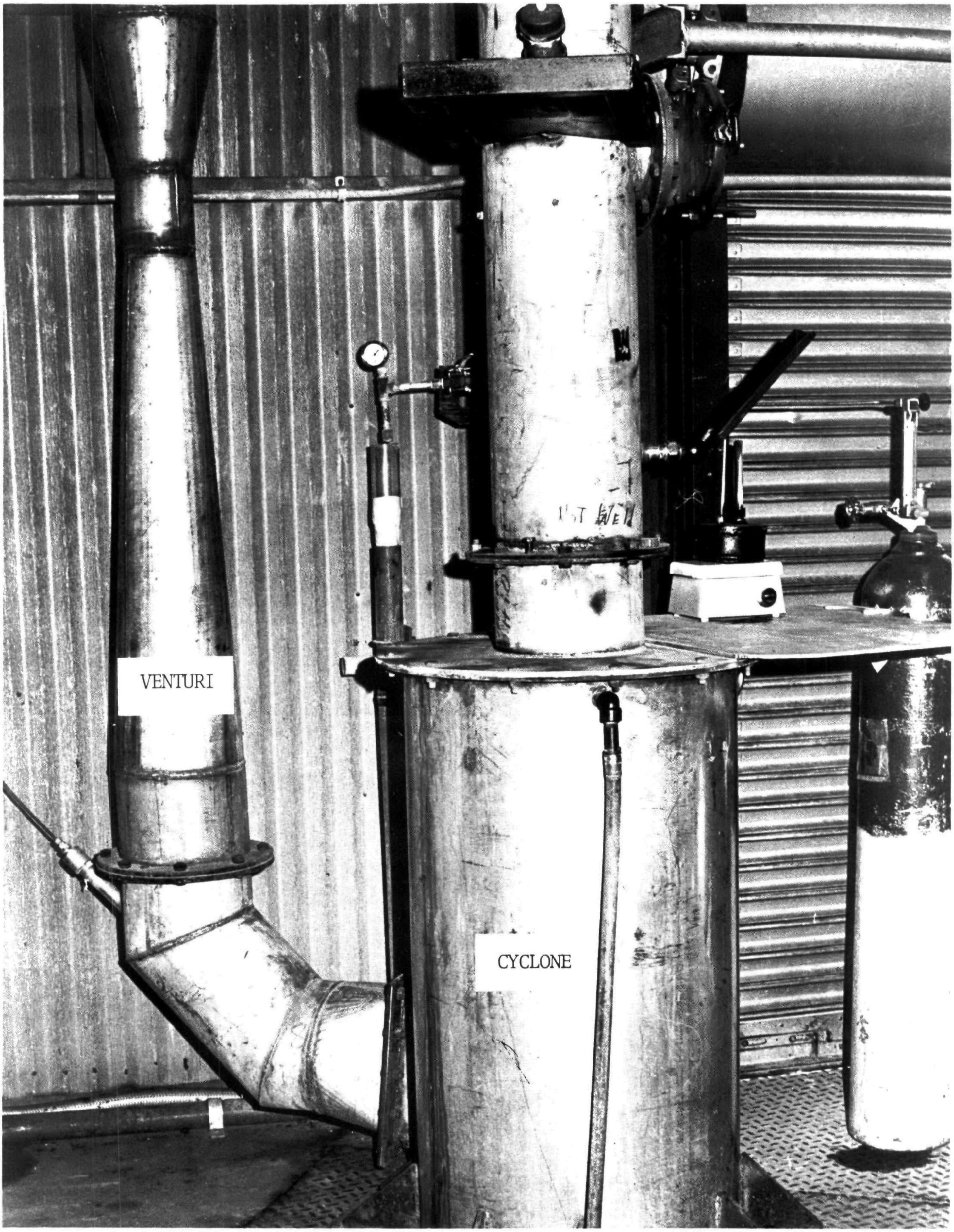


FIGURE 2.5. FLOATING BED ABSORBER

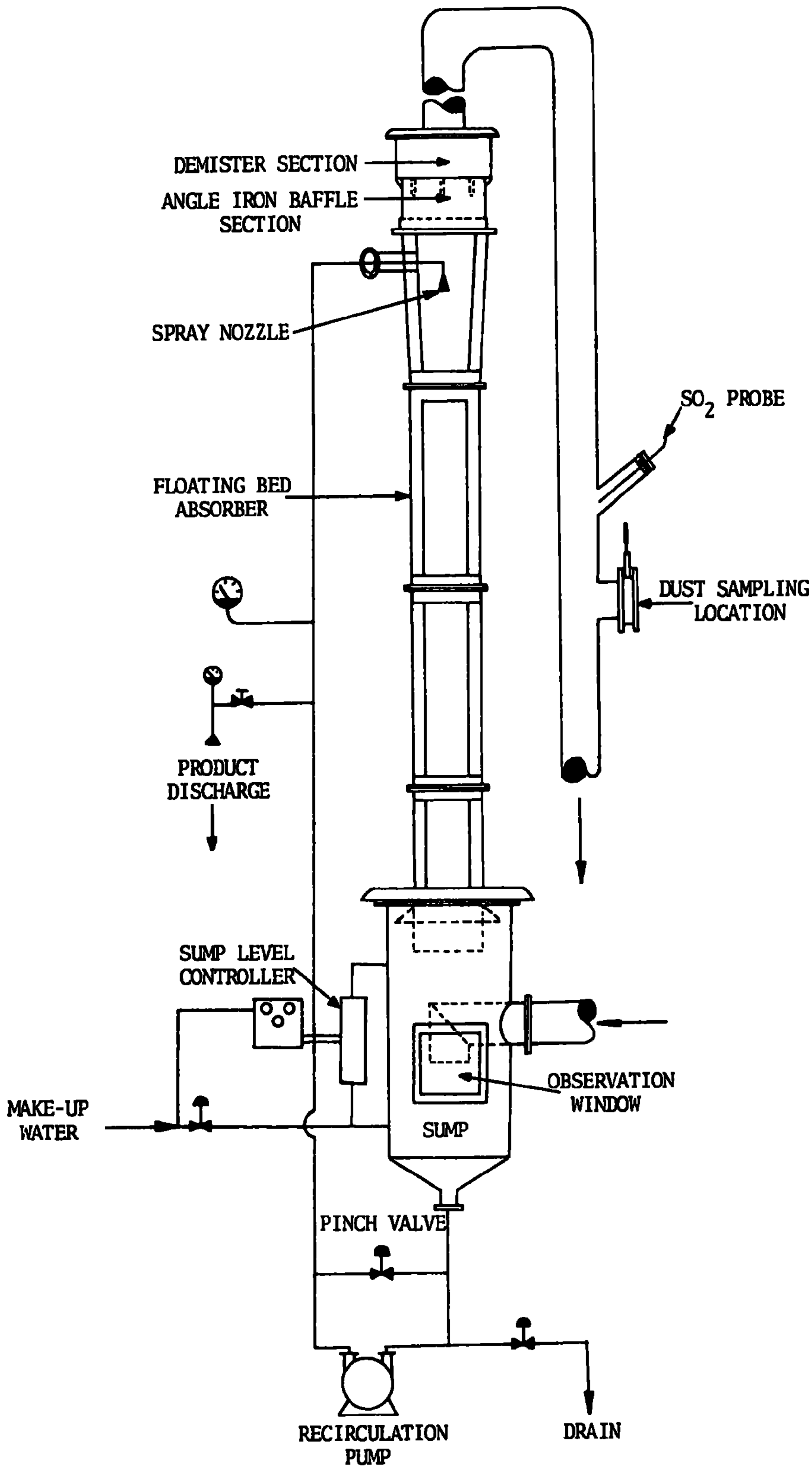


FIGURE 2.6. FLOATING BED ABSORBER

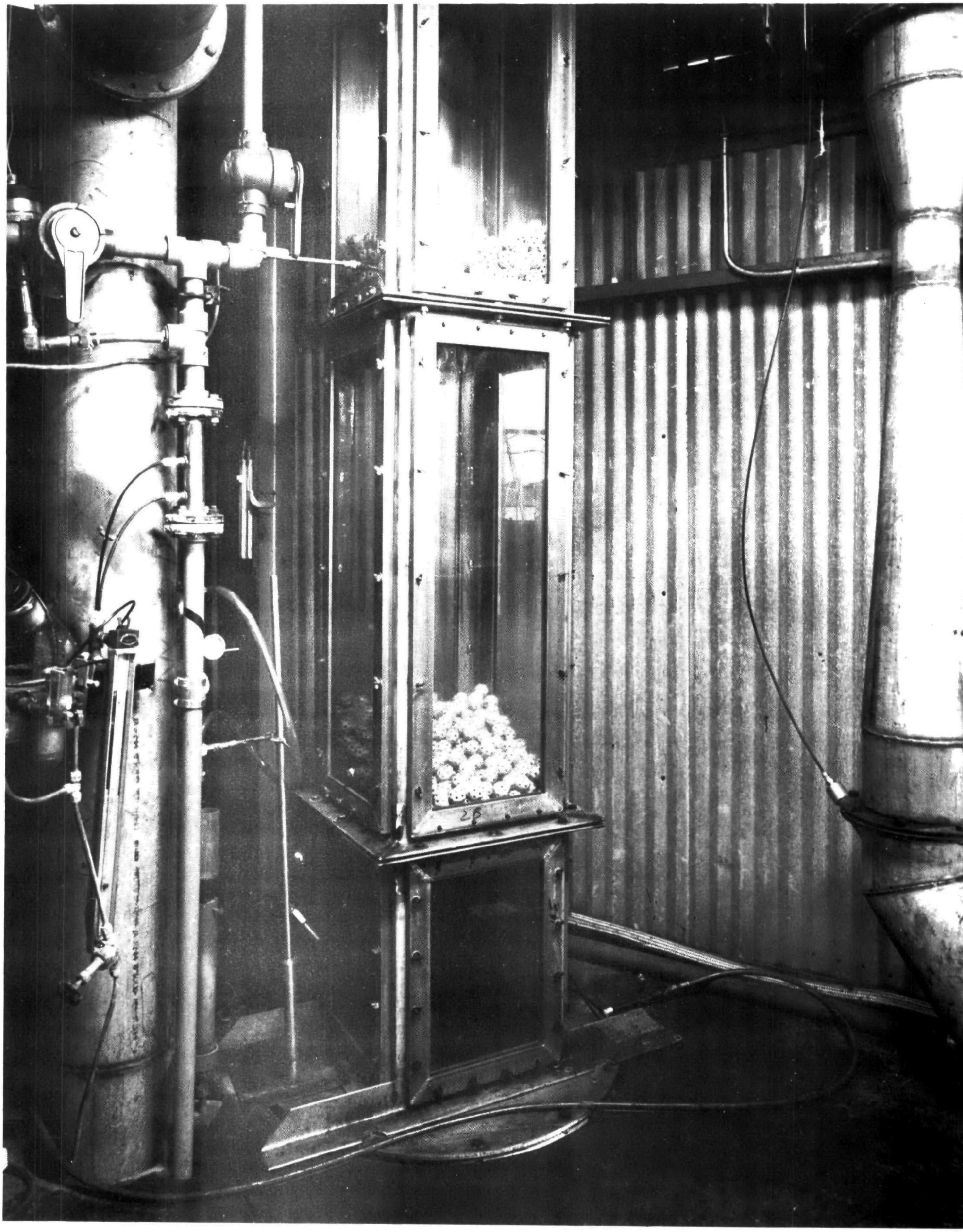


FIGURE 2.7. SLURRY ENTRAINMENT SEPARATOR SECTION

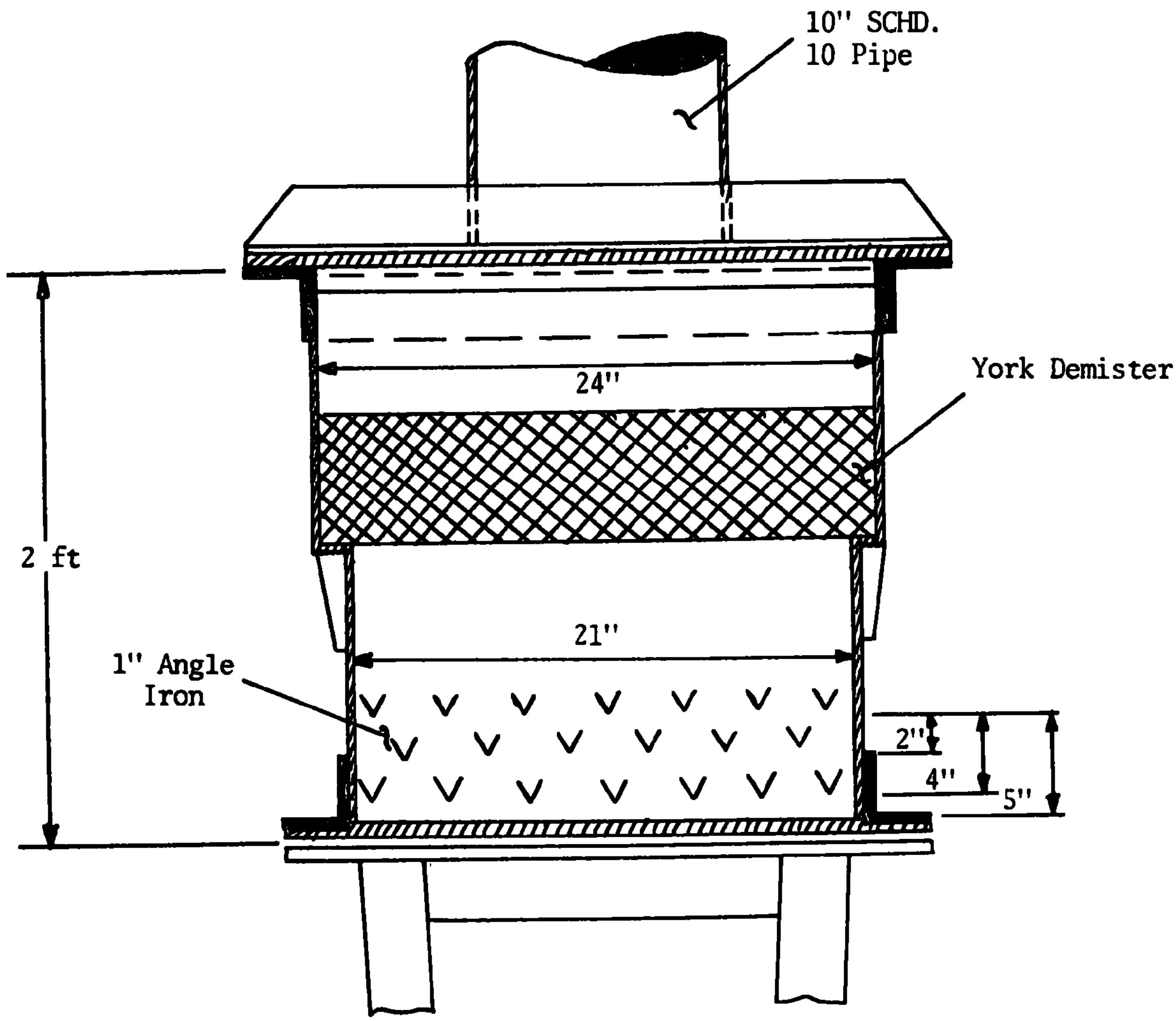


FIGURE 2.8. NO_2 INJECTION SYSTEM

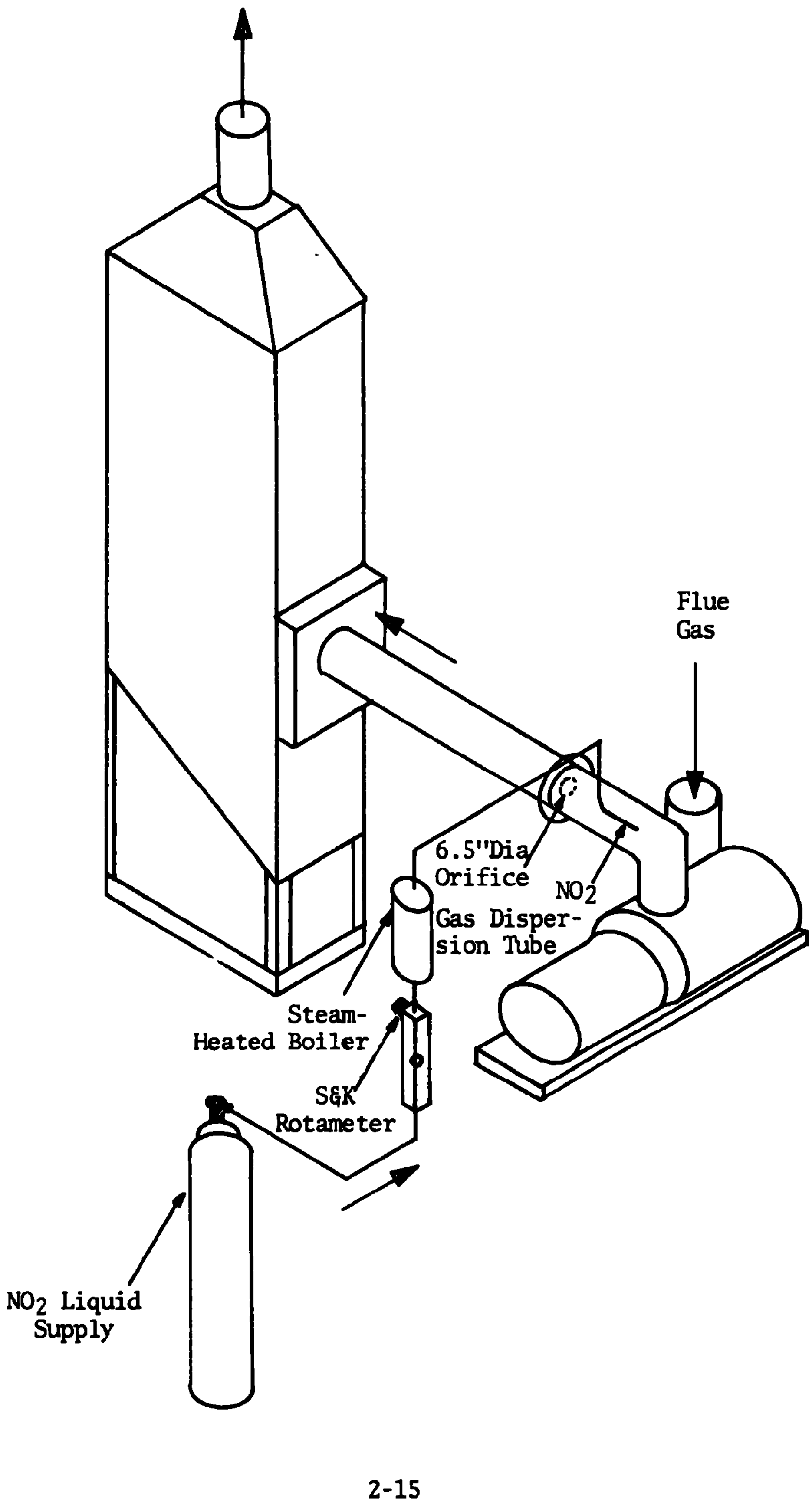


FIGURE 2.9. NO_X SCRUBBER DIMENSIONS

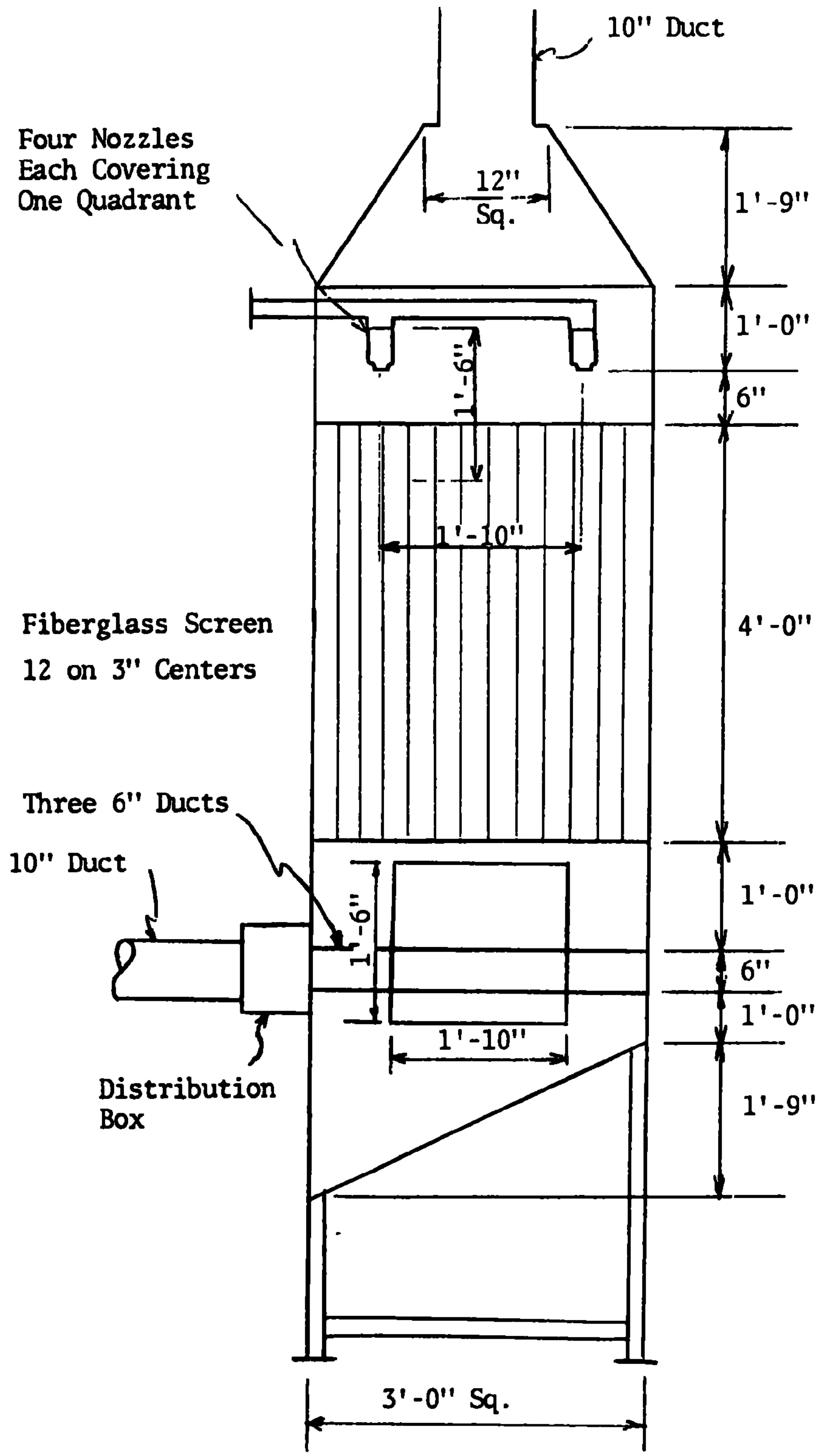


FIGURE 2.10. NO_X SCRUBBER

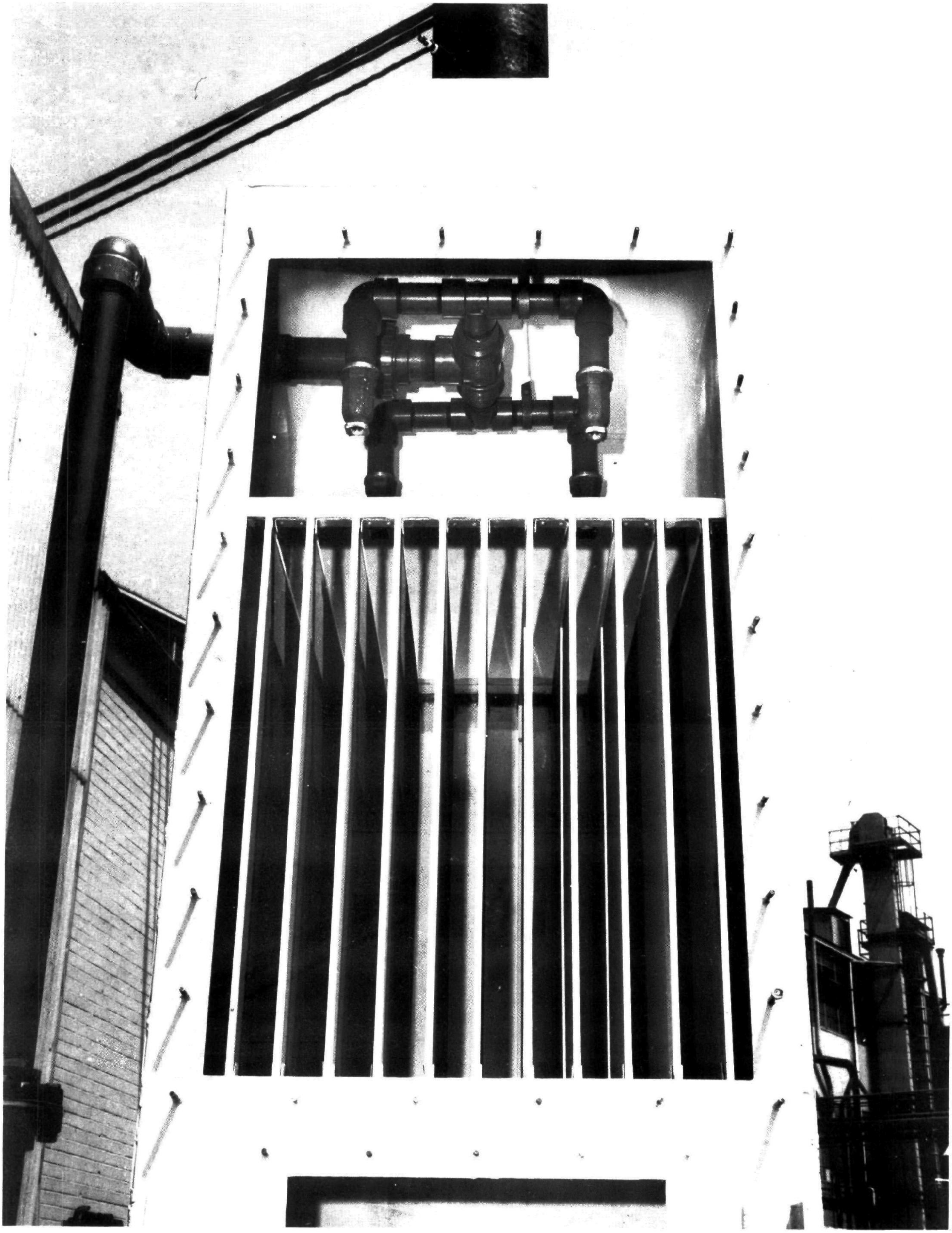


FIGURE 2.11. NO_X SCRUBBER AND LEACH BED

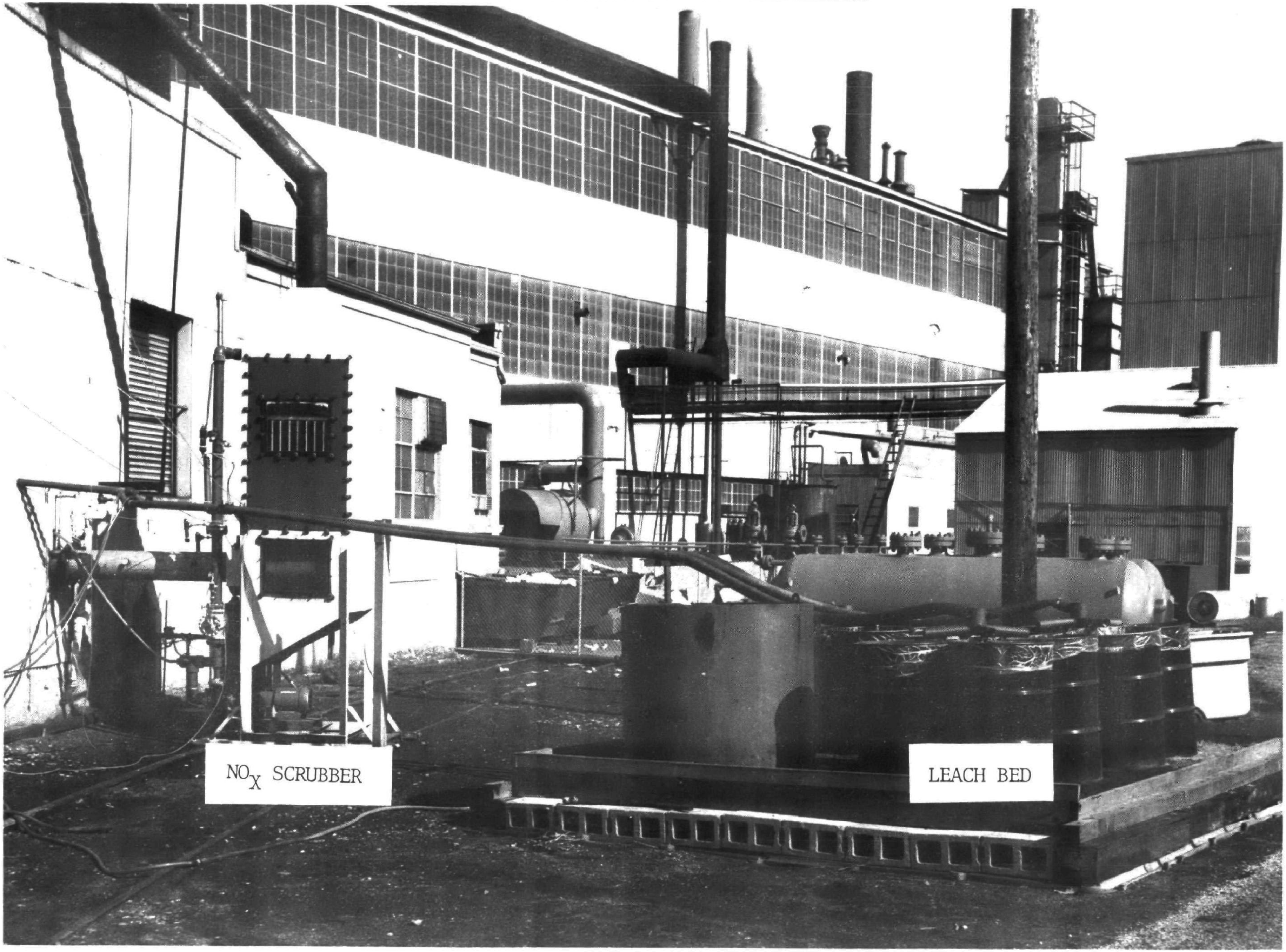
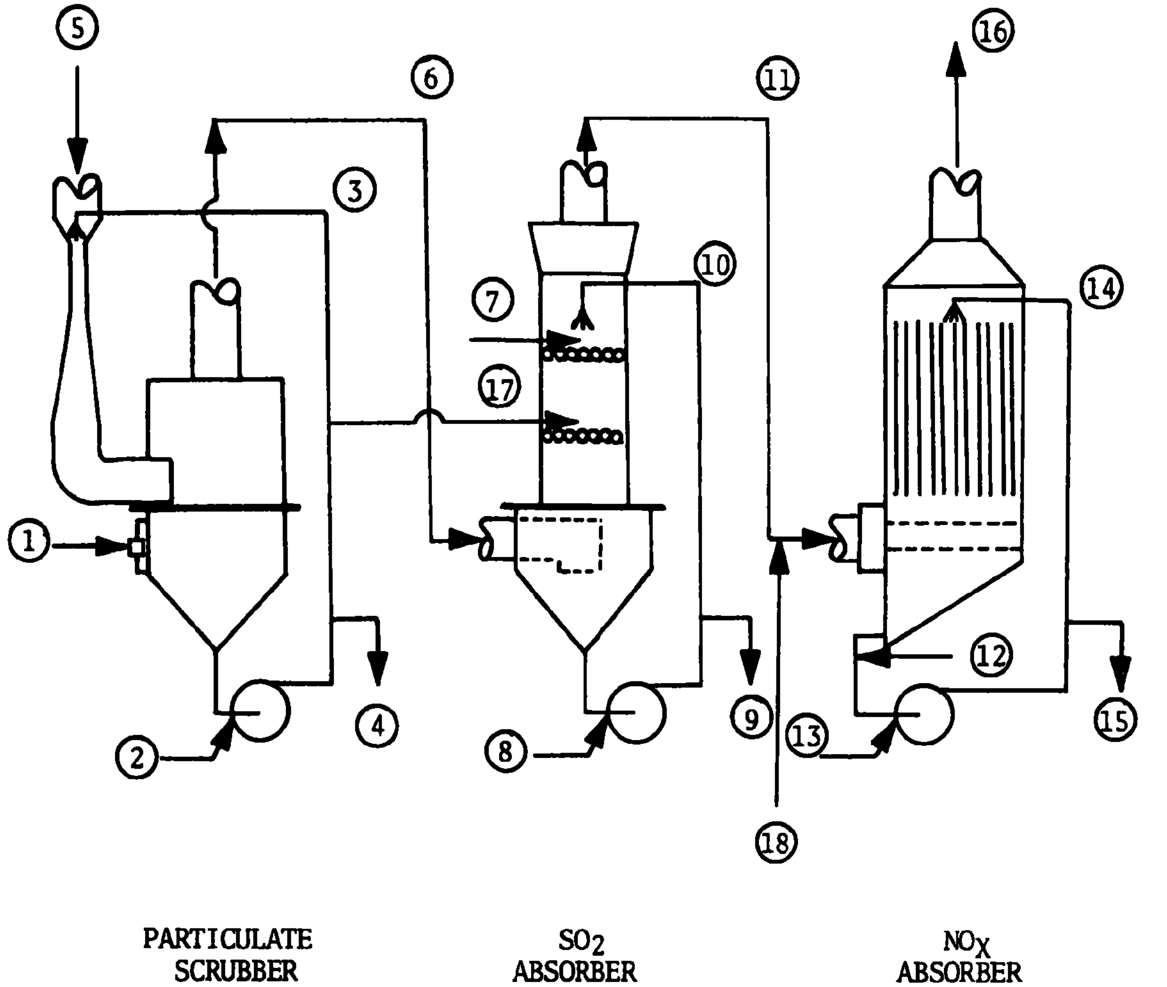


FIGURE 2.12. PILOT PLANT FLOW SCHEMATIC



	Stream	Nominal Flow Rates lb/hr		Stream	Nominal Flow Rates lb/hr
1	Makeup Water	750	10	Recirculated Spray	22,200
2	Seal Water	120	11	Flue Gas	4,600
3	Recirculated Spray	11,500	12	Makeup MgO	196
4	Product Fly Ash Slurry	540	13	Seal Water	120
5	Flue Gas	4,400	14	Recirculated Spray	76,500
6	Flue Gas	4,600	15	Product Slurry	327
7	Makeup MgO Slurry	286	16	Flue Gas	4,600
8	Seal Water	120	17	Fly Ash Slurry Bleed	60
9	Product Slurry	498	18	NO_2 Injection	2.1

3.0 TEST APPARATUS AND PROCEDURES

3.1 PLANT OPERATING TEST PROCEDURE

A day's testing began with the startup of the furnace. First, the air heaters were fired and allowed to reach temperature (∿750°F). This usually took an hour. The coal feed was then ignited. The furnace gases at this time were vented directly to the atmosphere via the stack relief. A waiting period of approximately 1 to 2 hours followed until the furnace ignition was stable.

While waiting for the desired furnace conditions, the particulate scrubbing system and the FBA were being readied for operation. During this time the MgO makeup slurry was prepared to the proper concentration. When the furnace was ready, the relief valve was closed, thereby directing the flue gas to the scrubbing systems.

After the transfer of gas was made, it usually took an hour after the MgO makeup was started before the chemical composition of the FBA reached steady-state. Steady-state was assumed when two or three Palmrose analyses taken at 10-minute intervals showed that the system had reached the desired operating conditions and also when the SO_2 concentration at the pilot plant exit was constant and less than 50 ppm.

The NO_2 scrubber was started by filling the sump with MgO slurry and recirculating the slurry. During the startup period no slurry was added nor withdrawn. The NO_2 flow was set as soon as the NO concentration was known. The liquid level was maintained at as low a level as was consistent with good pump operation. This insured a more rapid approach towards steady-state. It took at least one hour to reach steady-state in the NO_X scrubber. A typical test lasted for about an hour, during which a complete set of data was taken.

During a test several samples were taken and put into storage in the event that they were needed at a later date. If certain data were found to be unusual, an analysis of the stored samples could provide a means for determining what occurred. Samples collected and stored in 8-ounce bottles consisted of the following: MgO makeup slurry, particulate cyclone slurry, FBA slurry, NO_X scrubber slurry, and a makeup water sample.

After a test was completed, the operating conditions were changed for the next test. Depending upon the operating parameter changed, there was usually a waiting period of about 1/2 to 1 hour before steady-state was again reached and the next test could begin.

3.2 FLUE GAS ANALYSIS

3.2.1 General Analysis

The method employed for SO_2 analysis was primarily the Barton coulometric titrator as previously described.[3] The sampling arrangement is shown in Figure 3.1. At the beginning of these tests a second approach for SO_2 analysis was attempted. This involved the use of a DuPont 460 SO_2/NO_2 Analyzer. This UV analyzer has been used successfully on in-plant experiments on a particulate free synthetic flue gas. However, during this test the DuPont continuously registered SO_2 concentration 150 to 250 ppm higher than the Barton. The discrepancy was investigated by measuring the SO_2 concentration with the Reich iodine titration method.[4] The Reich method was found to agree with the Barton titrator. The possibility that particulate matter was causing an SO_2 interference on the DuPont 460 was then explored analytically. It was deducted that flue gas containing 0.015 grains/DSCF and a $\bar{D}_{32}$ of 0.25 micron could produce the observed discrepancy. These values are certainly within the range of possibility. Thus, the DuPont was dropped as an SO_2 monitor.

Fly ash and SO_3 concentrations were not measured during this test program.

3.2.2 NO_X Analysis

It is generally recognized that the measurement of the oxides of nitrogen is a difficult task. The circumstance here was even more so since the split between nitric oxide (NO) and nitrogen dioxide (NO_2) was required. To accomplish this the following methods were specified:

1. Phenoldisulfonic acid (PDS) for NO + NO_2.
2. Saltzman for NO_2 only.
3. Dynasciences "Fuel Cell" for NO only.

It became evident, however, that neither of the latter two methods were selective. The result of this situation was, therefore, to obscure the analysis of the data. The application of these methods are described below.

The PDS method was the primary means employed for determining overall performance.

PDS analyses were taken at three points: the FBA exit, the NO_x scrubber inlet, and the NO_x scrubber exit. Figure 3.2 depicts the sampling locations for all three locations.

A typical PDS sampling and analysis consists of the following. To a 1000 ml flask is added an absorbing solution consisting of hydrogen peroxide and dilute sulfuric acid. The flask is then evacuated; a gas sample is now ready to be taken. The line to the other analyzers is pinched off, and one arm of the three-way stopcock is connected to the tee. The stopcock is opened, and the gas sample is drawn into the flask.

The nitrogen oxides are converted to nitric acid by the absorbent solution and are then reacted with phenoldisulfonic acid to produce a yellow compound, which is measured colorimetrically. The color is measured with a photometer and compared with calibration curves made with a solution containing a known amount of nitrate.

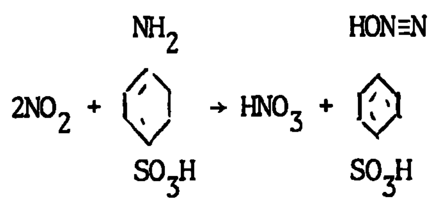
A more complete and descriptive explanation of the phenoldisulfonic acid method used in these tests is given in the American Society for Testing and Materials, Standard Method of Test for OXIDES OF NITROGEN IN GASEOUS COMBUSTION PRODUCTS (PHENOL-DISULFONIC ACID PROCEDURE), ASTM Designation: D1608-60. With the exception of the following modifications, the ASTM Method was followed as written:

Modifications to ASTM Method:

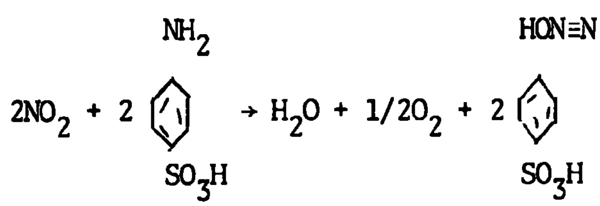
1. Absorbent Solution - 2 ml of H_2O_2 (3%) was added to 50 ml of 0.1N H_2SO_4. This is about four times the peroxide concentration called for in the ASTM Standard.
2. In place of 1N sodium hydroxide solution, 1N potassium hydroxide solution was used.

The Saltzman method of analysis employed for these tests is a modification by Strom[5] which permits the use of the Saltzman method for high concentrations of NO_2. A detailed description of the method is attached in Appendix A. The intent of the Saltzman method was to analyze for NO_2 only in the flue gas. However, it became evident during the tests that both NO and NO_2 were being analyzed. This observation was made in spite of the fact that Saltzman points to the observation that NO does not interfere substantially with the analysis. However, he did not perform his analysis with an $NO\text{-}NO_2\text{-}N_2$ gas mixture but rather with an $NO\text{-}N_2$ mixture.

The Saltzman analysis for samples containing only NO_2 depends upon the following two reactions proceeding at approximately the same rate:



(3-1)



(3-2)

where the aromatic on the left is sulfonilic acid and the aromatic on the right is the diazosulfonilic acid.

If the disproportionating reaction (3-1) was much faster than the oxidation reaction (3-2), then one mole of NO_2 would produce only one half the color as one mole of sodium nitrite. If the reverse were true; i.e., if reaction (3-2) was faster, then one mole of NO_2 would develop the same color as one mole of $NaNO_2$. As Saltzman reports, however, both reactions are significant and one mole of NO_2 yields only as much color as 0.73 moles $NaNO_2$.

Now in the present system with mixtures of NO and NO_2, a third reaction is possible which makes it quite difficult to determine the sodium nitrite equivalency for the mixture; namely,

$$NO + NO_2 \rightarrow N_2O_3 \xrightarrow{H_2O} 2HNO_2 \qquad (3\text{-}3)$$

Both nitrous acid anhydride (N_2O_3) and nitrous acid (HNO_3) are at the same oxidation state. The extent to which reaction (3-3) takes place will affect that equivalence between NO_X ($NO + NO_2$) and the sodium nitrite. For instance, if equimolar quantities of NO and NO_2 were present in the sample when taken and if reaction (3-3) predominated, then the NO_X-$NaNO_2$ equivalence would, of course, be unity. Since reaction (3-3) is a gas-phase reaction while reactions (3-1) and (3-2) are aqueous reactions, it is quite possible that reaction (3-3) does indeed predominate. Table 3.1 summarizes the expected sodium nitrite equivalence for various ratios of NO_2/NO assuming reaction (3-3) is far faster than the other two reactions. For example, if 15 minutes elapsed between the time that a sample containing 600 ppm NO is drawn and the time that the sample is analyzed, 84% of the original NO can be oxidized to NO_2. See Figure 3.3.

It is apparent from Table 3.1 that unless some aleternate means is available to determine the NO_2/NO ratio, the correct equivalence, C_{eq}, cannot be assigned. There are fortunately means available by which the ratio can at times be estimated as will be shown later.

Finally, since the gas sample is injected into the septum bottle, which is filled with air, significant oxidation of the NO can take place by the time the sample was analyzed.

The Dynasciences NX-130 monitor was employed with the hope of being able to monitor only NO from the NO_X mixture. Refer to Figure 3.2 for a description of the sampling arrangement. Although this monitor is designed to measure both NO and NO_2, it was hoped that by passing the flue gas through Mallcosorb the NO_2 could be quantitatively removed. As was evident from the tests, this was not the case. Specifically, when monitoring flue gas at the FBA exit and the NO_X scrubber inlet with NO_2 being injected in between, the apparent NO_X concentration increased substantially. With a bias voltage of 0.4 volts across the fuel cell, the relationship between monitor response and gas composition is as follows:

$$y'_{NO_X} = y_{NO} + 0.53\ y_{NO_2}$$

where y'_{NO_X} = apparent NO_X concentration, ppm by volume
y_{NO} = NO concentration, ppm by volume
y_{NO_2} = NO_2 concentration, ppm by volume

Thus, unless the ratio of NO to NO_2 is known the NX-130 monitor output is difficult to translate. It is known, however, from combustion kinetics that the NO_X split at the furnace exit is essentially all NO. However, given sufficient time and oxygen within the flue gas, the NO will partially oxidize to NO_2. Likewise as NO_2 forms it can further react with NO to form N_2O_3 and/or HNO_2, the latter constituent very likely being removed in the Mallcosorb.

To investigate the above question the following analysis is presented. Since the N_2O_3 formation is probably much faster than the NO oxidation, an equilibrium conversion of N_2O_3 (HNO_2) can probably be assumed. It would follow then that if we started with 600 ppm NO (at furnace exit) and assumed also that the flue gas contains 3% oxygen, then by the time the flue gas passed to the FBA exit sampling point and through the sample line to the Mallcosorb at the NX-130 monitor, a period of ∿ 60 seconds, ∿ 20 ppm NO_2 could have formed (see Figure 3.4). At 80°F about 16 ppm HNO_2 could also have formed (see Figure 3.5). The HNO_2 would most likely be removed in the Mallcosorb. Thus, the NX-130 would have registered as follows:

$$y'_{NO_X} = (600 - 20) + (0.53)(21 - 16/2) = 587 \text{ ppm}$$

This is an error of only 2%. However, when the NX-130 is monitoring the NO, NO_2, H_2O mixture at the NO_X scrubber inlet and exit, the potential for erroneous answers is substantially increased. For instance, assume the following typical condition:

$[NO]$ = 600 ppm

$[NO_2]$ = 600 ppm

$[H_2O]$ = 15.1% at 130°F

≈ 6.5% at 100°F

TEMP. BULK GAS = 130°F

TEMP. SAMPLED GAS = 100°F

From Figure 3.5 the equilibrating HNO_2 is 106 ppm and 148 ppm at 100°F and 130°F respectively. Since the HNO_2 will be absorbed into the Mallcosorb at 100°F, the apparent NO_x on the NX-130 will be:

$$NO_x' = (600 - 106/2) + (0.53)(600 - 106/2) = 573.5 + 303.5 = 837 \text{ ppm}$$

This amounts to an error of 30%.

The net result of the discussion presented above is that because of several NO_x measuring problems, a significant uncertainty exists in all the NO_x values with the possible exception of the PDS method. That is, there is no interpretive problems with the PDS method except for its usual characteristic scatter.

In summary, the NO_x analyses will be interpreted in this report as follows:

1. PDS: Standard Procedure.
2. Saltzman: The nitrite equivalence (C_{eq}) will be assumed to equal 1.0.
3. Dynasciences NX-130: Valid only on NO_2 free samples.

3.3 LIQUID ANALYZER

The sulfite, MgO, and suspended solids analysis procedures performed on all three process streams were identical to those used during the previous work.[6] No sulfate analyses were performed on the FBA product. However, sulfate, nitrite, and nitrate analyses were all performed upon the NO_x scrubber recirculated slurry. The sulfate analysis used was the standard gravimetric analysis of precipitated barium sulfate. The nitrite analysis was the ASTM method D-1254-67. Finally, the Brucine Alkaloid Method was used for the nitrate analysis.

TABLE 3.1. SODIUM NITRITE EQUIVALENCE FOR MIXTURES OF NO AND NO_2

NO_2/NO	C_{eq}
> 1.0 (excess NO)	1.0 (excess NO will be missed)
1.0	1.0
1.2	0.975
1.4	0.955
∞ (no NO)	0.73

FIGURE 3.1. SO_2 SAMPLING SYSTEM

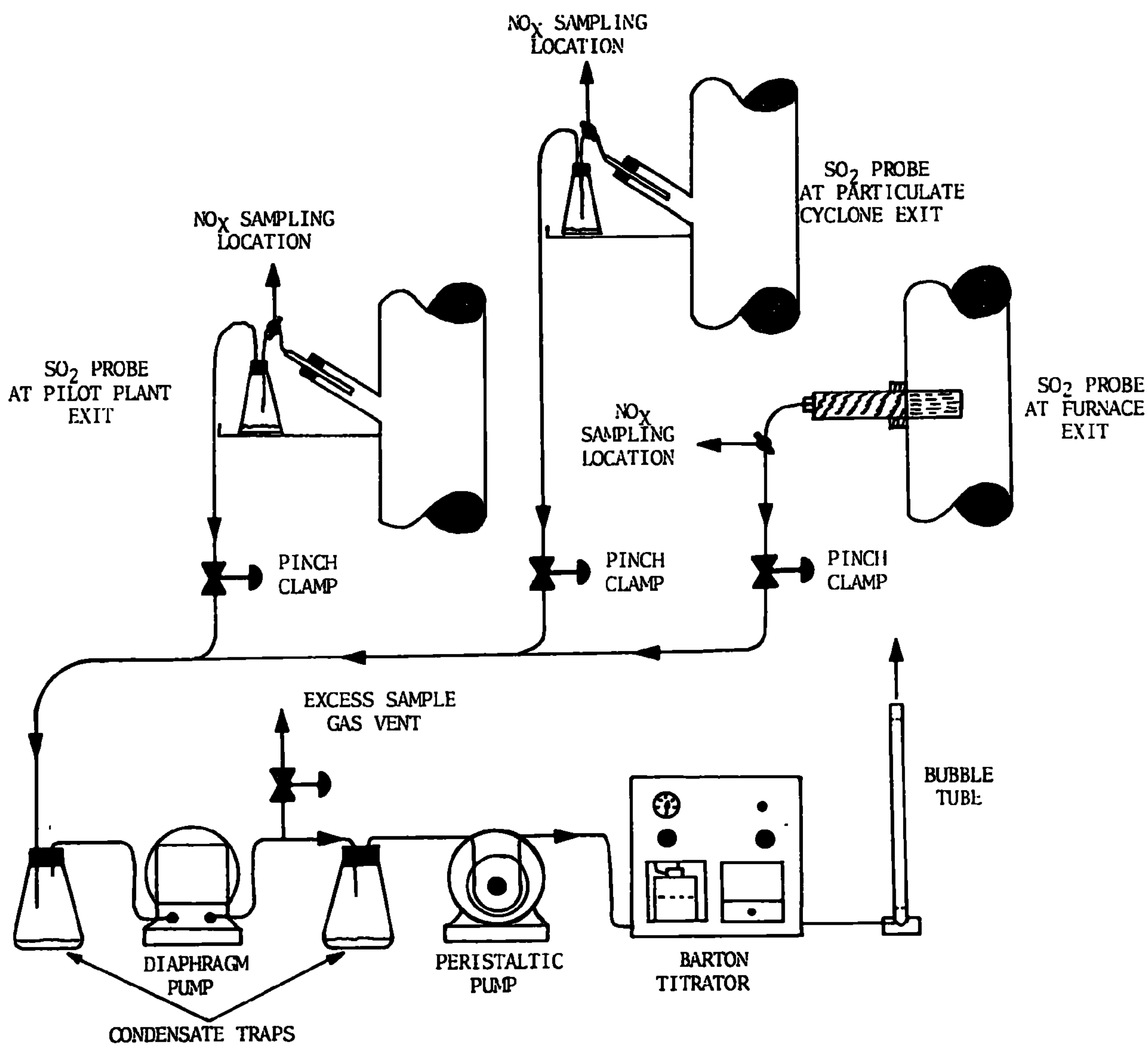
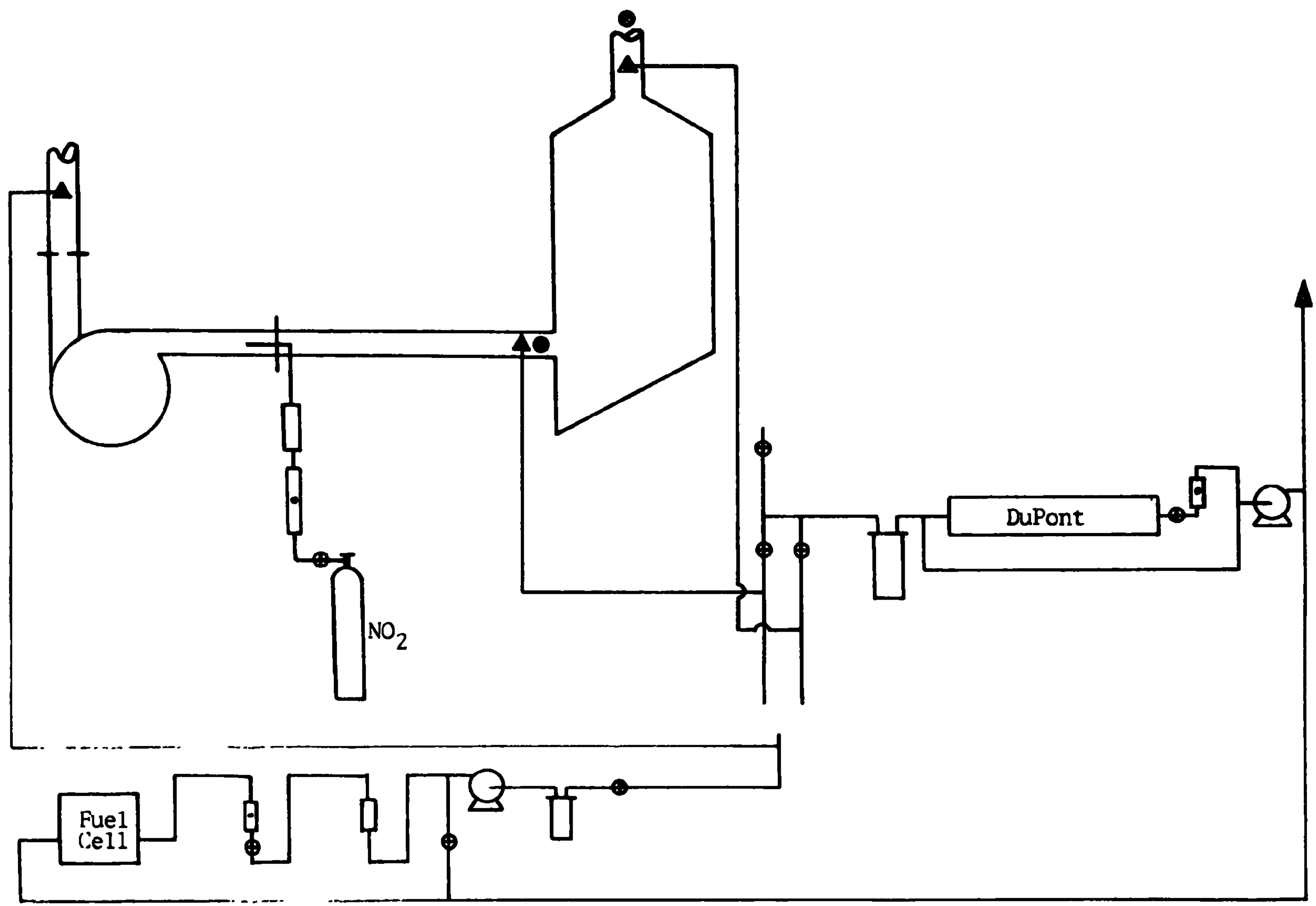


FIGURE 3.2. NO_X SAMPLING SYSTEM



● Saltzman Sampling Location

▲ Fuel Cell Sampling Location

⊕ Control Valve

FIGURE 3.3. NO OXIDATION RATE IN AIR

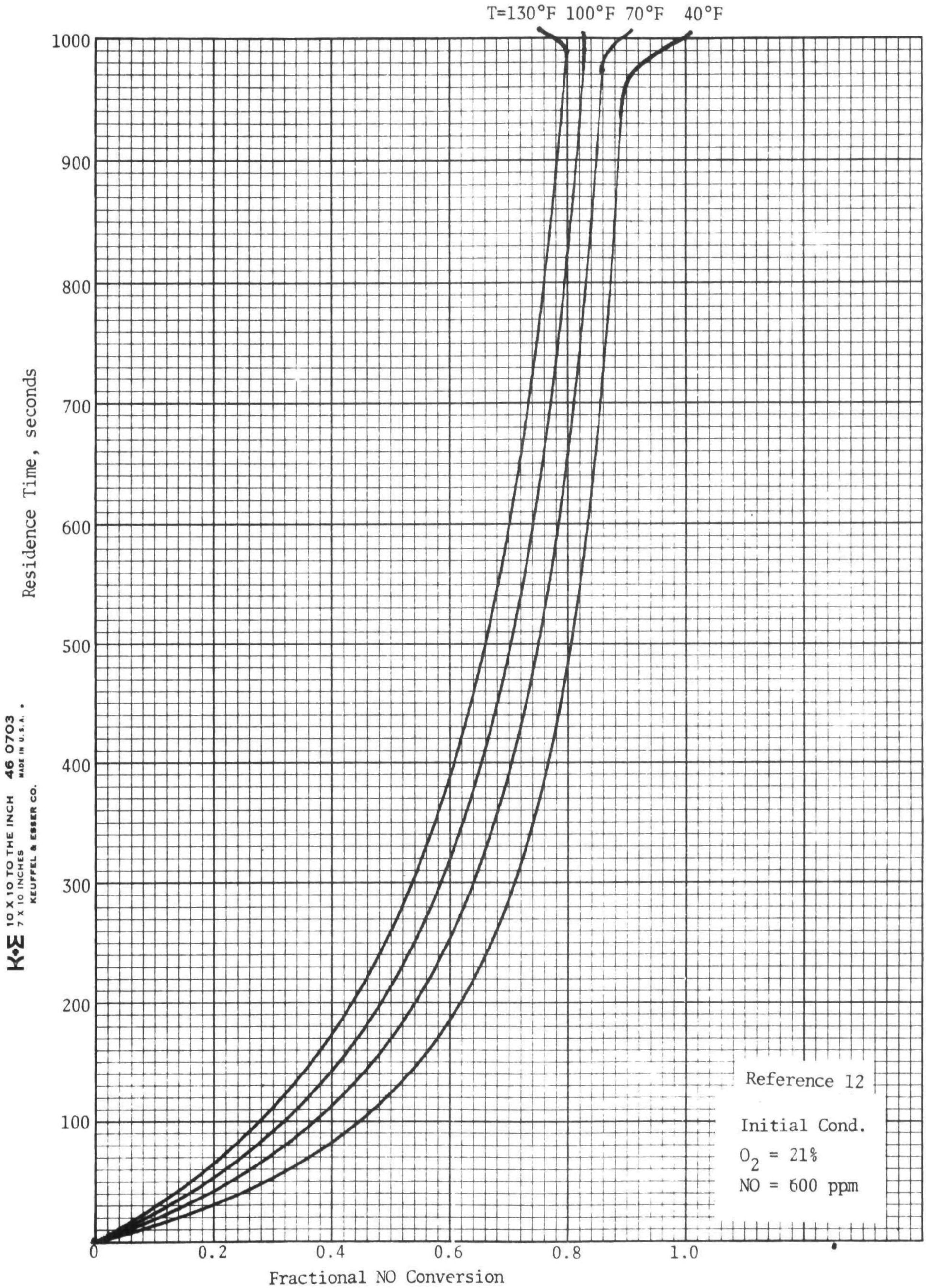


FIGURE 3.4. NO OXIDATION RATE IN FLUE GAS

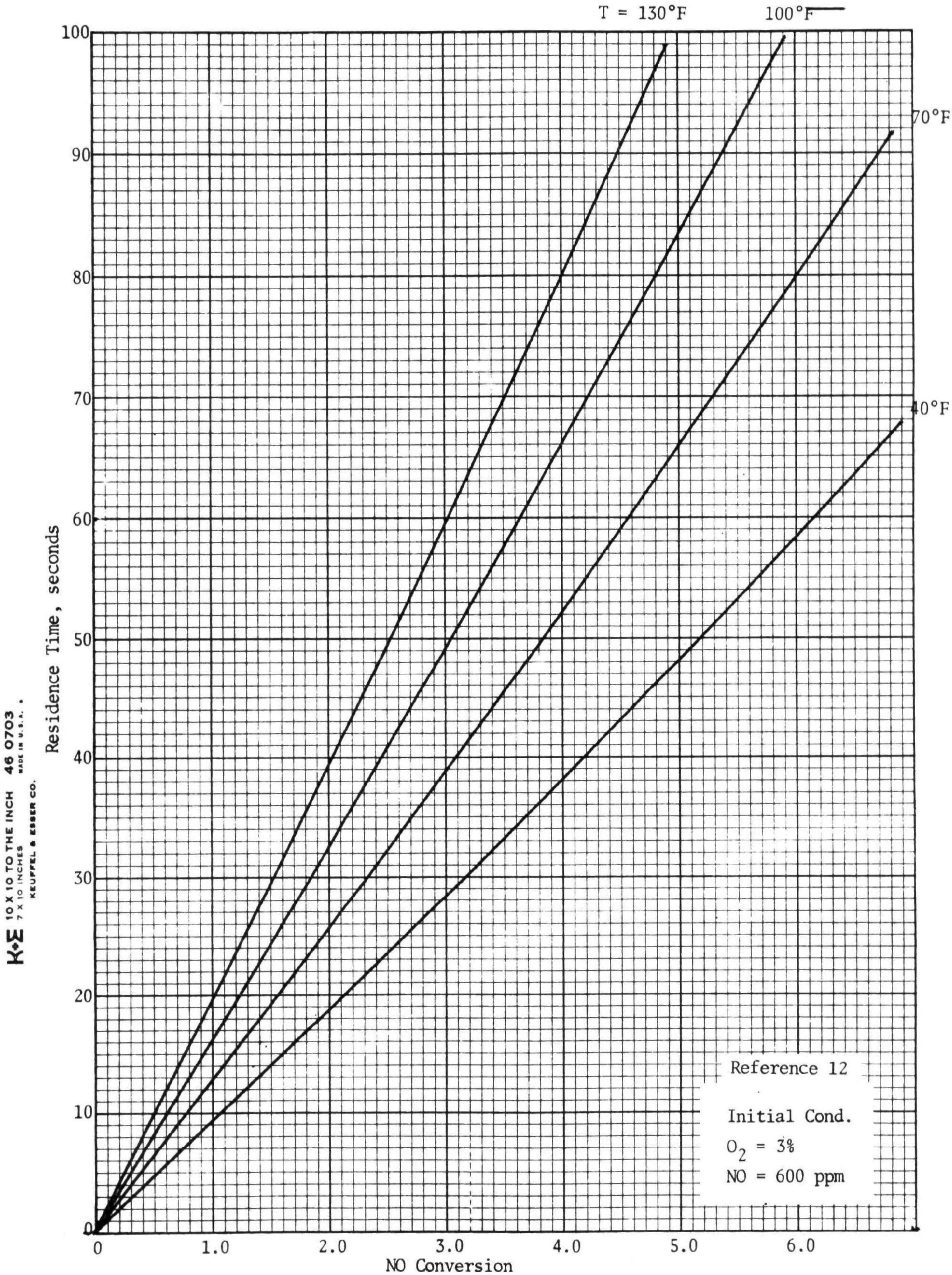
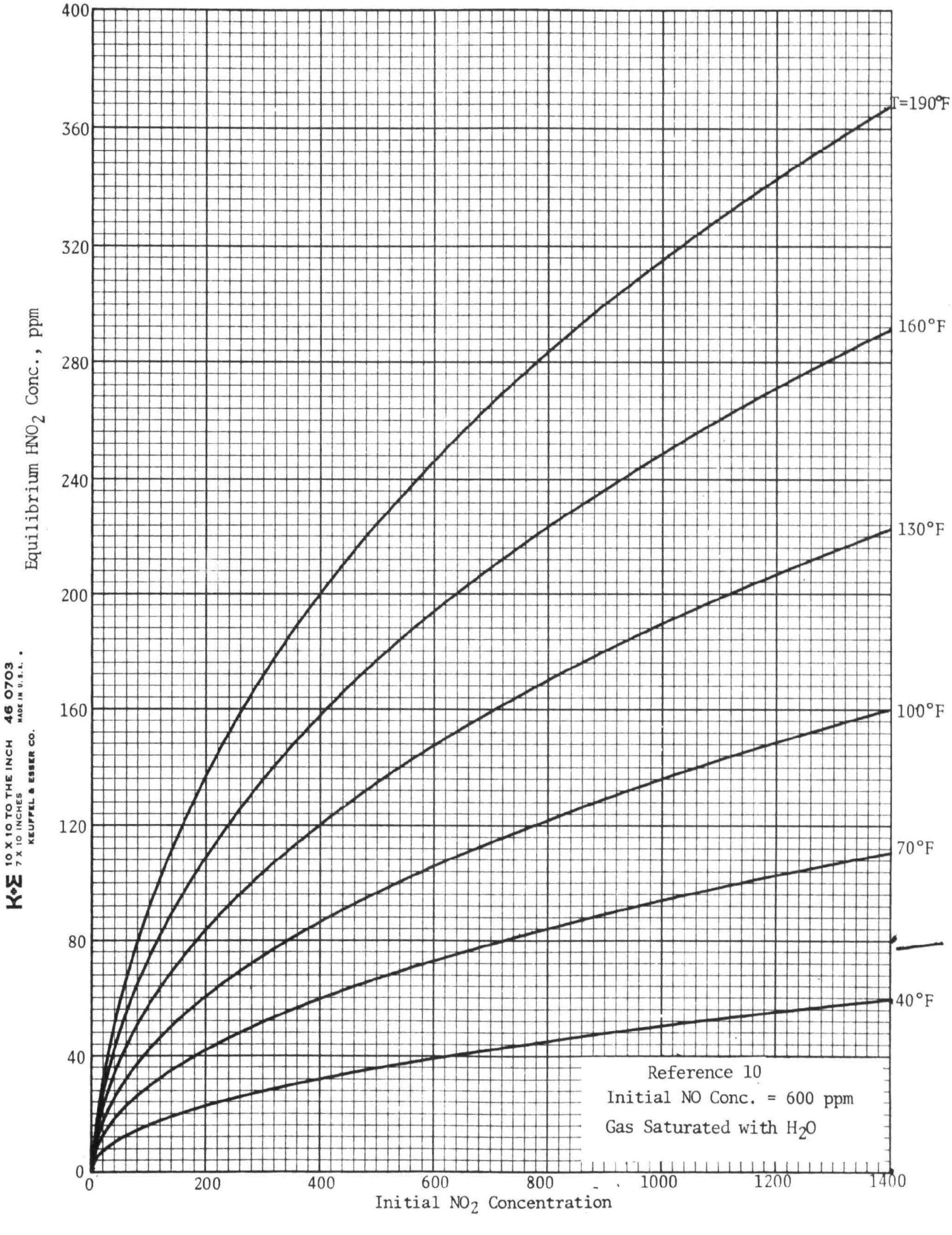


FIGURE 3.5. EQUILIBRIUM HNO_2 CONCENTRATIONS



4.0 RESULTS

Since the singular purpose of these tests was to evaluate the feasibility of NO_X absorption in flue gas containing dilute concentrations of SO_2, the NO_X scrubber system was the only equipment which was subjected to variable control. The remainder of the pilot plant was maintained under constant operating conditions. However, some pertinent observations were made with regards to the rest of the system. Therefore, before reporting on the results of the NO_X scrubber, the operation and observation of the particulate scrubber and FBA will be reported. All of the computerized data and results are included in Appendix B.

4.1 OVERALL RESULTS

4.1.1 Particulate Scrubber

The particulate venturi scrubber was operated at about 5 to 6 inches w.g. over the entire course of these tests. The liquid spray rate amounted to 20 gal/MCF. These conditions are comparable to the previous tests.[7] SO_2 performance was also similar. The only difference observed was that while previously the slurry pH varied from 2.0 to 3.5, during these tests the pH varied from 4.0 to 5.5. This is probably due to the presence of an alkaline constituent in the ash.

4.1.2 FBA

During the previous work[8] the FBA was the major subject of study. During the present program its sole function was to reduce the SO_2 concentration to below 50 ppm. To accomplish this a set of operating conditions were specified as follows:

Slurry pH	Greater than 7.0
Liquid-to-Gas Ratio	Greater than 4.0 lb/lb

Unslaked MgO was used exclusively and at a sufficient rate that the pH was maintained at about 8.0. Fly ash slurry from the particulate scrubber was added intermittently. This was done because during the previous work the presence of fly ash in the slurry prevented the formation of deposits in the sump and piping of the FBA. The results of operation of the FBA in this fashion are as follows:

1. Exit SO_2 concentrations were at all times less than 50 ppm. The nominal value was 14.2 ppm.
2. Although no deposition problems were experienced in the FBA piping, for the first time deposition occurred on the underside of the bottom tray. This condition was severe enough to completely close the tray holes. To a lesser extent deposition also began on the underside of the top tray. This material was analyzed by X-Ray diffraction analysis and the results given in Table 4.1. The only identifiable operating difference is the continuous operation at elevated pH's (∿8.0). Only intermittent operation under these conditions was covered in the previous tests. A photograph of the deposit is shown in Figure 4.3.

4.2 NO_x SCRUBBER RESULTS

4.2.1 NO_x Absorption

Because of the analytical problems described in Section 3.2.2, discrimination of the data and evaluation of the degree to which NO_x was absorbed is quite limited. Table 4.2 shows the parameters which were tested and also depicts the run number designation used here. That is, the tests were numbered successively but were assigned a letter which depicts the condition which was to be set up. For instance, Run 10-G was the tenth test and was specified to evaluate NO_x absorption at test condition G in Table 4.2.

The primary results can be summarized as follows:

1. Under none of the conditions tested was any significantly observable reduction in NO_x concentration experienced across the NO_x absorber.
2. The NO_x scrubber operated without difficulty except for a considerable degree of carryover leaving the top of the scrubber. For a period, this carryover affected the analysis by creating a difficult sampling situation.

All of the major results are summarized in Table 4.3. The most interesting factor to note is the NO_x measurements by the NX-130 and the PDS. The former analysis depicts a reduction in NO_x concentration in several tests. Significantly the PDS method not only does not indicate the same reduction but in fact indicates an increase NO_x concentration across the scrubber in several instances. This probably is due to the variance in the PDS method.

4.2.2 SO_2 Absorption

After several of the scheduled tests were completed and the lack of performance was evident, the suitability of the design of the NO_X scrubber became a concern. To evaluate the scrubber design a test was run whereby the scrubber could be evaluated as a sulfur dioxide absorber. This was accomplished by operating the FBA deficient of MgO. Flue gas containing 1350 ppm SO_2 entered the NO_X scrubber. No NO_2 was added to the flue gas. The results are shown in Figure 4.2. These results reveal several facts. First, the K_ga for SO_2 absorption although only about one third as great as for the FBA is still adequate to produce large and measurable changes in SO_2 concentration. Secondly, the fact that SO_2 absorption changed significantly with changes in the liquid spray rate means that either the wetted area changes significantly with the liquid spray rate or that a significant liquid-phase effect is present. This liquid-phase dependence could be either the liquid-phase diffusion coefficient k_2 or a reaction rate effect such as the following:

$$MgO_{(s)} + H_2O \rightarrow Mg^{++} + 2OH^- \quad (4\text{-}1)$$

$$SO_2 \cdot H_2O + 2OH^- \rightarrow SO_3^= + 2H_2O \quad (4\text{-}2)$$

Reaction (4-1) represents the dissolution of MgO which could be the limiting step in either the SO_2 absorption or NO_X absorption systems.

Although no data exists with regards to the diffusivity of HNO_2 in the gas phase, if it does not differ greatly from SO_2 (by a factor of 2 to 3), then the SO_2 results will be useful in interpreting the NO_X results as will be shown in the following section.

TABLE 4.1. ANALYSIS OF DEPOSIT SAMPLES

Chem Lab No.	M-24801	M-24802	M-24803
Sample Description	Soft Sample from Center	Incipient Deposit from Corner	Bulk Sample from Edge
X-Ray Diffraction (Crystalline Constituent)			
Major	$MgSO_3 \cdot 6H_2O$	$MgSO_3 \cdot 6H_2O$	$MgSO_3 \cdot 6H_2O$

TABLE 4.2. PARAMETER STUDY SPECIFICATIONS

Test Condition	NO_2/NO	L/G	Stoich.	Recirc. Slurry Conc.	Load	Number Tests
A	1.0	15	1.5	2.5%	100%	4
B	0.7	↓	↓	↓	↓	1
C	0.0	↓	↓	↓	↓	2
D	1.3	↓	↓	↓	↓	1
E	1.0	10	↓	↓	↓	1
F	↓	5	↓	↓	↓	1
G	↓	15	2.0	↓	↓	1
H	↓	↓	3.0	↓	↓	1
I	↓	↓	1.5	5	↓	1
J	↓	↓	↓	10	↓	1
K	↓	↓	↓	2.5	50	2
						16 Two Tests/Day

TABLE 4.3. SUMMARY OF RESULTS

Test Number	1-C	2-A	3-E	4-F	5-K	6-L	7-C	8-B	9-D	10-G	11-H	12-A	13-A	14-I	15-A	16-K	17-J
NO_X by PDS																	
FBA Exit	124.8	420.7		502.4	589.4		563.4	580.4		608.8	469.5	501.6	580.9	528.6	547.5	627.7	576.6
NO_X Scrubber Inlet	233.4	1122.1	969.3	759.5	671.3		504.1	906.0	1026.2	766.0	913.9		525.8	1310.9	971.8	866.3	1194.6
NO_X Scrubber Exit	209.1	901.3	1180.9	855.0	920.6		550.4	947.5	717.5	1709.5	274.1	762.0	580.3	1076.8	1136.4	886.4	1223.1
NO_X by Saltzman																	
NO_X Scrubber Inlet		876.9	930.3	613.9	901.6		324.2	802.1	937.1	680.8	696.2	442.0	662.5	689.1	694.9	642.5	609.6
NO_X Scrubber Exit			986.7	751.1	1226.1		311.1	566.9	857.8	491.6	509.7		256.4	492.4	471.8	449.4	451.1
NO_X by Fuel Cell																	
Furnace Exit	870.3	485.8	485.6	561.9	588.1		733.2	759.6		692.4	748.7	748.6	674.2	648.7	785.5	715.7	815.7
FBA Exit	902.0	485.8	504.3	486.9	559.6		695.6	873.6		645.6	664.4	655.0	730.4	614.9	835.8	403.2	704.9
NO_X Scrubber Inlet	686.0	803.4	644.4	580.6	777.8		714.4			729.9	786.1	842.2	664.8		795.6	846.8	856.0
NO_X Scrubber Exit	635.2	308.3	551.1	299.7	398.4		629.8		773.6	655.0	505.3	617.6	725.7		845.9	514 1	916.4
Ratio NO_2/NO																	
PDS	0.87	1.67		0.51	0.14		-0.11			0.26	0.95		-0.09	1.48	0.78	0.38	1.07
F.C. & Rotameter	0.00	2.29	2.24	1.55	1.45		0.00			0.65	0.65	0.67	0.63	0.76	0.59	0.92	0.70
SO_2 by Barton																	
Furnace Exit	1007.6	1862.4	1649.6	1538.4			1799.0	1688 7	698.0	1783.4	1801.2	1741.8	1713.5	1704.6	1675.5	1643.2	1951.5
Particulate Scrubber Exit	1138.6	1720.0		1431.0			1614.5	1557.1	698.0	1595.7	1479.5	1479.5	1116.7	1587.7	1369.9		1692.4
FBA Exit	10.3	3.5	9.4	10.3		1308.8	21.2	13.2	4.2	4.1	30.9	30.9	8.5	2.0	18.4	14.2	18.9
NO_X Scrubber Exit	6.0					22.8	8.3										
Gas Residence Time, sec	2.22	2.10	2.22	2.32	2.50	2.10	2.22	2.22	2.22	2.22	2.22	2.22	2.32	2.32	2.32	3.08	2.32
Gas Velocity, fps	1.8	1.9	1.8	1.7	1.6	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.3	1.7
L/G, lb/lb	21.4	19.2	13.6	8.5	12.5	19.1	19.9	20.2	20.2	19.9	20.3	20.4	22.0	22.0	21.5	17.6	21.8
Ratio Nitrite/Nitrate (Liq)	11.739	0.534	1.632	3.857	6.000	0.000		6.533	41.333	9.167	4.407	4.321	5.889	5.750	6.833	6.000	4.674
Flue Gas Flow Rate, lb/hr	3508.0	3913.0	3748 0	3541.0	3260.0	3927.0	3772.0	3719.0	3715.0	3761.0	3688.0	3684.0	3466.0	3460.0	3518.0	2726.0	3466.0

FIGURE 4.1. DEPOSITION ON UNDERSIDE OF FIRST FBA STAGE

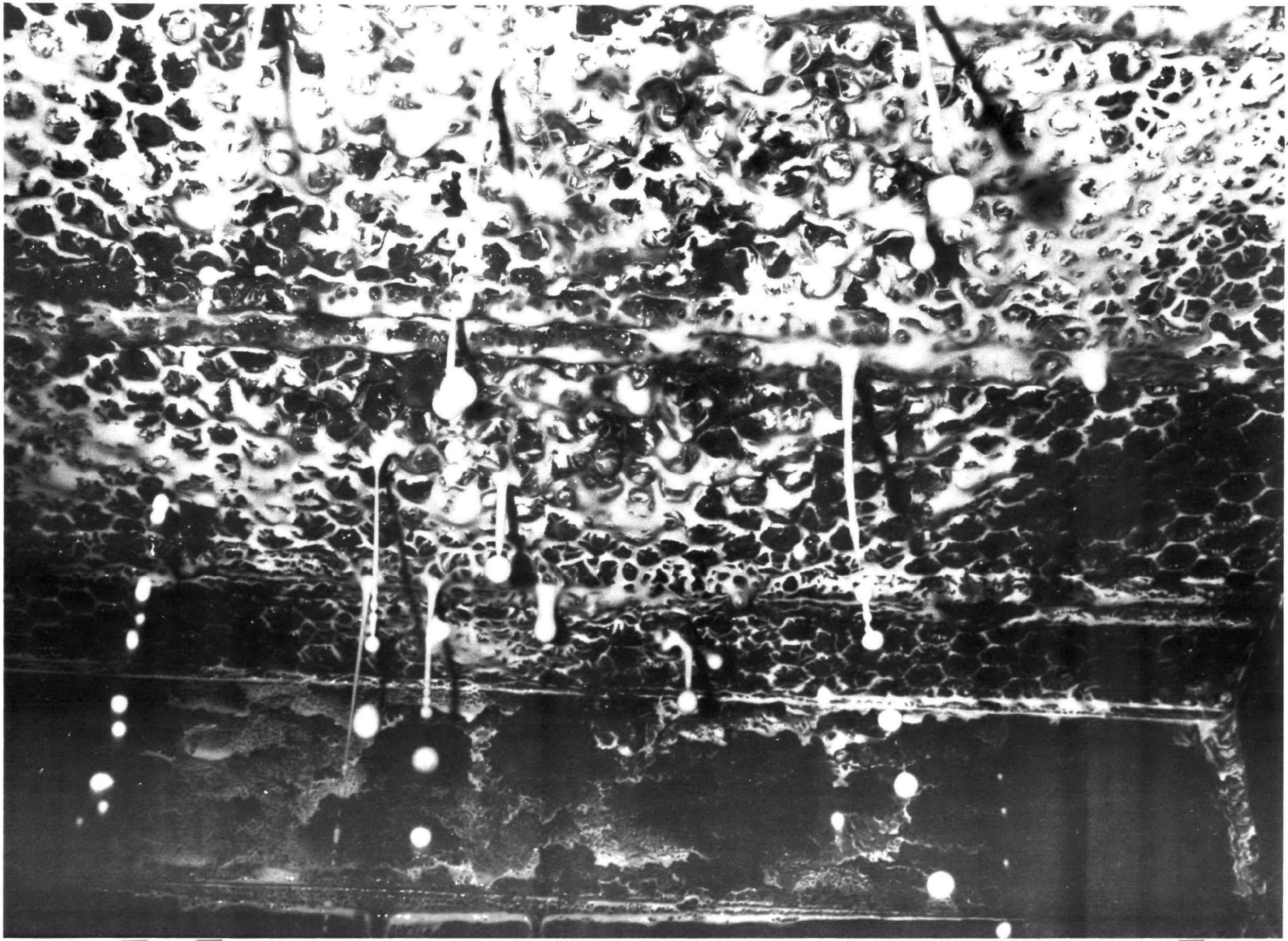
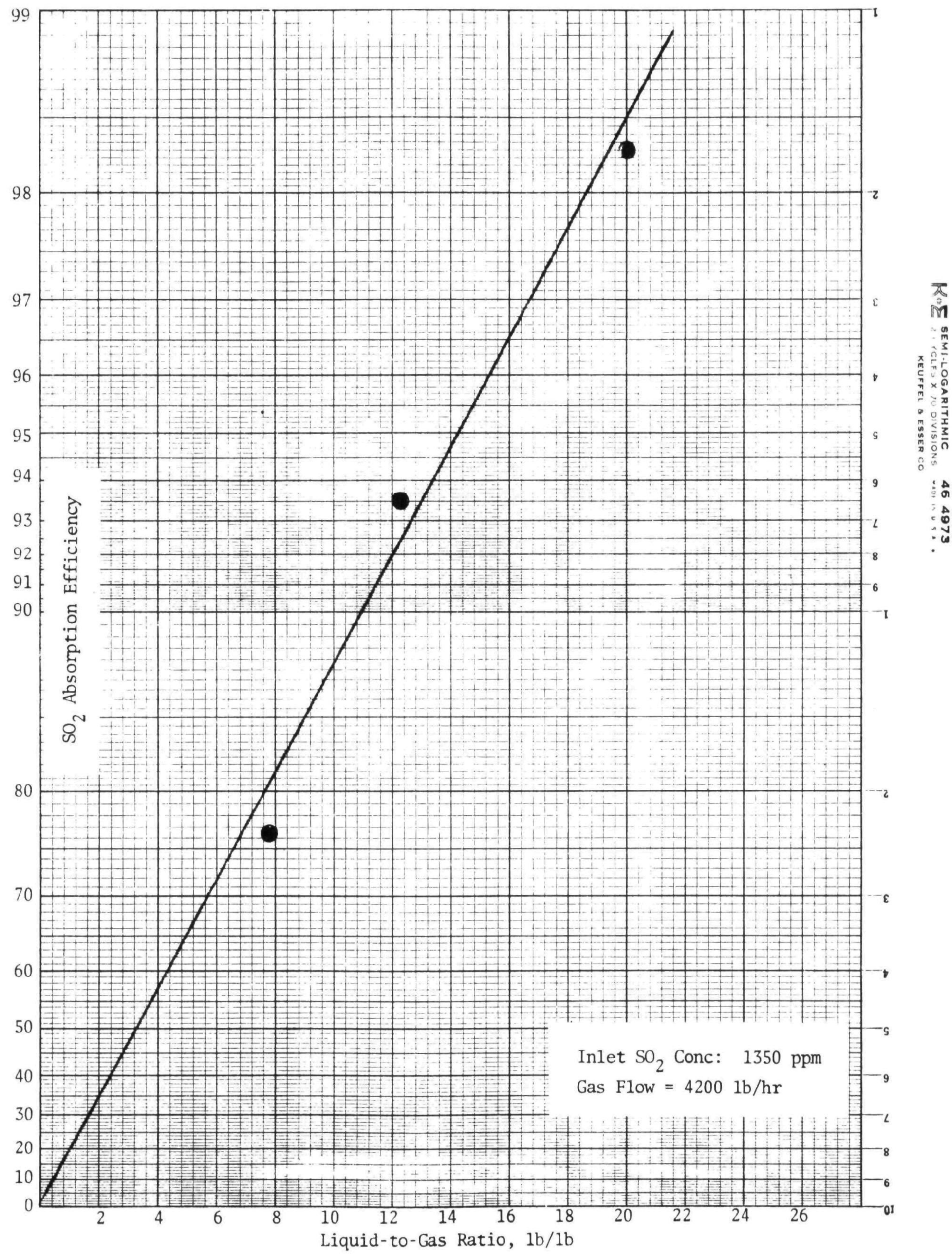


FIGURE 4.2. SO_2 ABSORPTION IN NO_X SCRUBBER



5.0 DISCUSSION

The purpose of the program was to experimentally study the feasibility of absorbing NO_x into magnesia slurry. Since the results were largely negative, the task remaining is to establish the degree to which these results reflect upon the general feasibility of NO_x absorption by wet scrubbing. That is, it can certainly be concluded that NO_x absorption into MgO in the apparatus tested is unsatisfactory and is therefore not a feasible approach. However, to what extent does the equipment design and the choice of alkali affect the feasibility of NO_x absorption by alkali scrubbing?

To approach this question a mechanism for this absorption must first be postulated. The model for which this research work was based and which is still felt to be valid is presented here.

It is well known that NO absorption into any aqueous medium is very slow owing to its extremely low solubility in water. Secondly, several people have studied NO_2 absorption, particularly with respect to nitric acid manufacture. Absorption is known to diminish rapidly with decreasing NO_2 partial pressure. NO_2 absorption efficiency greater than 50% is difficult to attain when inlet NO_2 concentrations are less than 1000 ppm. However, several experimenters have noted that NO_x absorption is enhanced when equimolar concentrations of NO and NO_2 are present in the gas phase. Quite obviously any absorption enhancement must be the result of a reaction between NO and NO_2 forming a substance more readily absorbed than either of the two reactants. That reaction is believed to be the following:

$$NO + NO_2 + H_2O \rightarrow HNO_2 + HNO_2 \quad (5\text{-}1)$$

In the wet scrubbing environment water vapor is present at very substantial levels. The above reaction probably takes place in two steps:

$$NO + NO_2 \rightarrow N_2O_3 \quad (5\text{-}2)$$

$$N_2O_3 + H_2O \rightarrow HNO_2 + HNO_2 \quad (5\text{-}3)$$

Little is known of the kinetics of reaction (5-1) except for the work done by Wayne.[10] He studied the formation of HNO_2 at 25°C and found the forward rate to be $k_f = 7.4 \times 10^4$ atm^{-2} sec^{-1}. Therefore, equimolar concentrations of NO and NO_2 initially at 1000 ppm each in a flue gas saturated with water vapor at 130°F and assuming that k_f equals its 25°C value, it would take 1.6 seconds to reduce the NO + NO_2 concentration to 200 ppm total. This conversion time is the first clue as to the contact time required for an NO_X scrubber relying on reaction (5-1).

However, gas-phase kinetics are not the only factor of importance in this system. First, it should be noted that chemical thermodynamics show that reaction (5-1) is reversible and in fact in the conditions under question conversion is relatively low (5 to 15%). This means that the HNO_2 concentration driving force for mass transfer will be severely limited. Finally, the gas absorption mass transfer rate of HNO_2 into the alkali solution can easily be limiting by this system for any one of several reasons. The first is quite obviously the small gas-phase driving force available; the second is the possible MgO dissolution lags; and the third follows from the long gas side residence times required which necessitates low gas Reynolds numbers which in turn create poor gas side mixing and mass transfer conditions.

The material balances for NO, NO_2, and HNO_2 across an element of volume as shown in Figure 5.1 lead to the following set of equations:

For HNO_2,

$$\frac{dy_1}{dZ} = \frac{1}{v_g} \left\{ r_1 - \frac{k_{1g}a}{\rho_g} (y_1 - y_1^*) \right\} \tag{5-4}$$

For NO,

$$\frac{dy_2}{dZ} = \frac{-1}{v_g} \frac{r_1}{2} \tag{5-5}$$

For NO_2,

$$\frac{dy_3}{dZ} = \frac{-1}{v_g} \left\{ \frac{r_1}{2} + \frac{k_{2g}a}{\rho_g} (y_2 - y_2^*) \right\} \tag{5-6}$$

where y_1 = HNO_2 molar concentration = p_1/p_T
y_2 = NO molar concentration = p_2/p_T
y_3 = NO_2 molar concentration = p_3/p_T
v_g = gas velocity, ft/sec
r_1 = kinetic rate of formation of HNO_2
ρ_g = molar density of bulk flue gas
a = specific mass transfer surface area, ft^2 surface/ft^3 scrubber volume
k_{1g} = gas-phase mass transfer coefficient for HNO_2
k_{2g} = gas-phase mass transfer coefficient for NO_2
y_1^* = HNO_2 gas concentration at the gas-liquid interface
y_2^* = NO_2 gas concentration at the gas-liquid interface

Now the kinetic rate of formation of HNO_2 is developed as follows:

Forward reaction:

$$\left.\frac{dy_1}{dZ}\right|_{\text{Forward}} = k_f \, y_2 \, y_3 \, H \qquad (5\text{-}7)$$

Reverse reaction:

$$\left.\frac{dy_1}{dZ}\right|_{\text{Reverse}} = \frac{-k_f}{K_{eq}} \, y_1^{\,2} \qquad (5\text{-}8)$$

where $K_{eq} = \frac{k_f}{k_r}$ = equilibrium constant
k_r = reverse reaction rate constant
H = molar water vapor concentration p_v/p_T

$\therefore$

$$r_1 = k_f \, y_2 \, y_3 \, H - \frac{k_f}{K_{eq}} \, y_1^{\,2} \qquad (5\text{-}9)$$

Several factors are significant from these equations (5-4) through (5-9). From equations (5-4) and (5-9) it is seen that if k_f is fast enough to maintain instantaneous equilibrium then the limiting factor will surely be the mass transfer rate. The maximum value of y_1 will be the equilibrium value.

From equation (5-5) it is seen that the only mechanism for reducing the NO concentration is to form HNO_2 which means, of course, that it is dependent on both the reaction rate and the mass transfer rate of HNO_2.

Equation (5-6) accounts for the fact that NO_2 can absorb directly in alkali solution. NO_2 absorption would be detrimental to the process in question since it would defeat the purpose of injecting NO_2 into the flue gas in the first place. Since experience has shown equimolar NO-NO_2 absorption to be superior to NO_2 absorption alone, it is evident that NO_2 absorption must be substantially greater than k_{2g}. It would seem more likely that since NO_2 is substantially less soluble in water than HNO_2, then it follows that $y_2 - y_2^*$ must be small compared to $y_1 - y_1^*$ (in spite of the small value of y_1). The relative degree to which these two constituents were absorbed in the present experiment can be examined from the product liquid analysis. NO_2 absorption will produce equimolar quantities of nitrite (NO_2^-) and nitrate (NO_3^-) in solution while HNO_2 absorption will produce only nitrite. See Table 4.2 for this ratio (NO_2^-/NO_3^-). These results confirm that HNO_2 was the predominant species absorbed.

To apply the above model to the present experimental situation, the following simplifying assumptions were made:

1. NO_2 absorption was negligible relative to HNO_2 absorption (supported by liquid analysis).
2. $y_1^* = 0$ (no liquid film or reaction effects). This is a weak assumption but will provide a limiting solution to the present case.
3. The geometry depicted in Figure 5.1 was used.
4. The surfaces were assumed to be fully wetted.

The model was applied to typical operating conditions as follows:

v_g = 2 ft/sec
T = 130°F
H = 0.151 moles water vapor/mole wet gas
ρ_g = 0.00232 lb moles/ft^3
K_{eq} = 0.465 atm^{-1}
a = 10 ft^2/ft^3

The mass transfer coefficient k_{1g} was determined from the Sherwood equation where:

$$N_{SH} = 0.023\ N_{Re}^{0.8}\ N_{SC}^{0.44} = \frac{k_c D}{D_f}$$

$$N_{Re} = 2480$$

$$N_{SC} = 0.94$$

∴ N_{SH} = 10.6
D_{eq} = 0.25 ft
D = 0.2 cm^2/sec

∴ k_c = 4.56 x 15^{-3} ft/sec
k_{1g} = 0.0764 lb mole/hr ft^2

Equations (5-4) through (5-9) were solved by numerical integration on an IBM 360 computer and showed that NO_x absorption would only be 2% for this case. The calculated $k_g a$ is only 0.764. This is an extremely low mass transfer coefficient. However, from the single SO_2 absorption experiment it is possible to obtain a measured value of $k_g a$ for this device. For comparable liquid recirculation rates the SO_2 experiment demonstrated a $k_g a$ equal to 15.8 lb moles/hr ft^3. Adjusting for differences in the expected diffusivities, the $k_g a$ for HNO_2 absorption would be as follows:

$$k_g a_{HNO_2} = k_g a_{SO_2} \left(\frac{D_{HNO_2}}{D_{SO_2}}\right) = 15.8 \left(\frac{0.20}{0.138}\right) = 23.0 \text{ lb moles/hr ft}^3$$

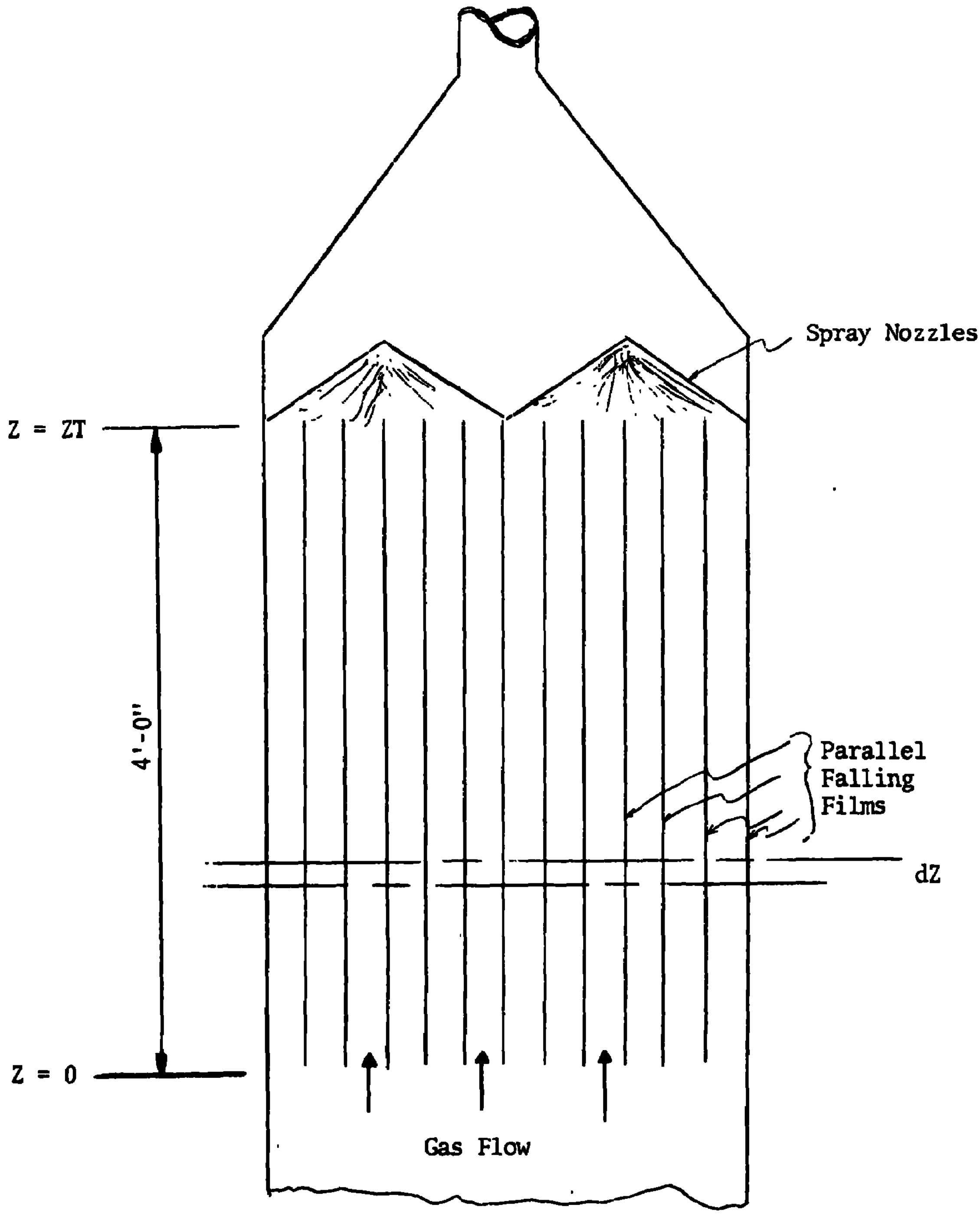
This $k_g a$ is nearly 30 times larger than that calculated from theory. This is obviously a better measure of $k_g a$ than the theoretical value. However, for this condition the NO_x absorption should have been 33%. For this magnitude of NO_x reduction, the measured change in total NO_x concentration across the scrubber would surely have been apparent in spite of the analysis difficulties. The conclusion to be drawn here is that a significant liquid film resistance must be present in the HNO_2 absorption situation. That is equivalent to saying that y_1^* is not negligible. To include y_1^* as a system variable would greatly increase the complexity of this model because it would require the coupling on liquid side material balances, liquid side diffusion equations, and liquid side chemical reaction kinetics. If it can be assumed that y_1^* is a linear function of y_1 for a fixed set of liquid and gas flow rates, then the $k_g a$ in equation (5-4) will be reduced by a constant and the solution to these equations will still be valid.

To evaluate the expected NO_x absorption performance over a broad range of $k_g a$'s and k_f's, this model was applied to the subject scrubber geometry and the results plotted in Figure 5.2. From this figure and from some facts regarding the process material balance, the potential feasibility of NO_x absorption in the subject apparatus can be established. First, consider the flow sheet in Figure 5.3 which depicts the minimum unit operations required of the process. The process design established the criterion that the NO_2 flow to the flue gas is just sufficient (no excess NO_2) to produce an equimolar quantity of NO and NO_2. Then the minimum NO_x absorption efficiency which will produce a self-sustained supply of NO_2 is 75%. This, however, will produce an overall NO_x efficient of only 50%. The NO_x concentration leaving the scrubber which will be acceptable to regulating agencies in light of the fact that 50% of the NO_2 would leave as NO_2, is highly questionable. Deferring the above question and addressing the question to technical feasibility only, the 75% absorption efficiency is the minimum acceptable scrubber performance. Then from Figure 5.2 it is seen that for $k_f = 7.3 \times 10^4 \text{ atm}^{-2} \text{ sec}^{-1}$, the $k_g a$ will have to be in excess of 72 lb moles/hr ft^3. This is as much as 100 times the apparent $k_g a$. There appears to be no physical manner in which sufficient contact surface area could be packed into a scrubber of this type to increase the $k_g a$ appreciably. It would appear that the system is liquid film mass transfer or chemical reaction rate limiting and at least for the MgO base, would probably not perform even under very extreme design changes. If the MgO dissolution step is the limiting factor, then for a soluble base such as sodium carbonate the apparent $k_g a$ would only need to be increased from 23 lb mole/hr ft^3 to 72 lb mole/hr ft^3. This is certainly a feasible physical possibility. For a soluble base, a packed tower seems to be the most appropriate device for this function.

Summarizing, it is concluded that NO_x absorption into a slurry of MgO is not a technically feasible approach for power plant application within the confines of reasonable equipment design. However, based upon the arguments presented above, it is quite possible that NO_x absorption into a soluble alkali base may be feasible. The appropriate apparatus would seem to be a conventional packed tower.

A final factor which can be drawn from the above analysis is that the absorption process can be highly temperature dependent. Increasing temperature will increase the water vapor concentration, the forward reaction rate constant, the equilibrium conversion of HNO_2, and finally the gas-phase diffusion coefficient. All of the above, of course, will increase HNO_2 absorption.

FIGURE 5.1. GEOMETRY ASSUMED FOR NO_X ABSORPTION



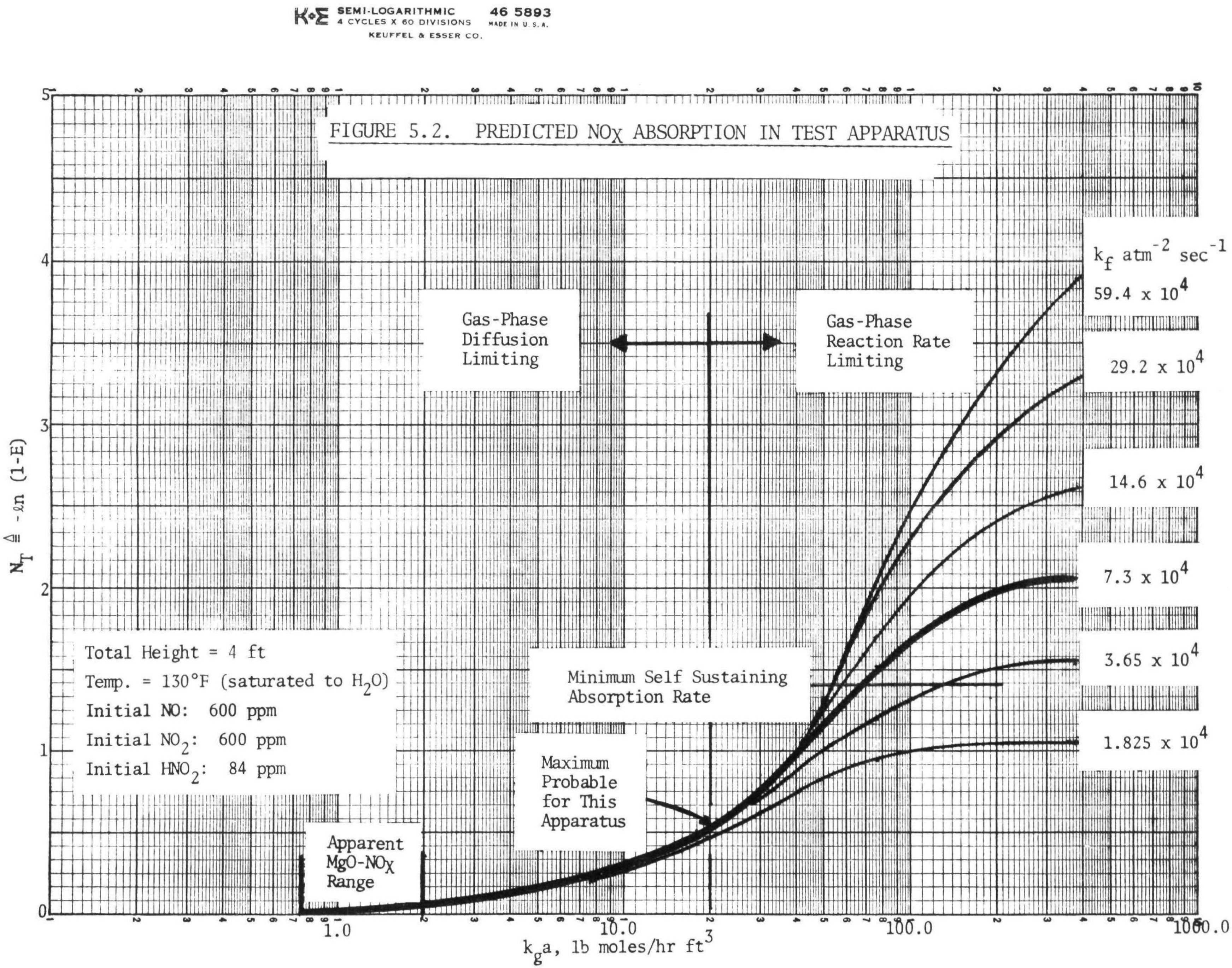
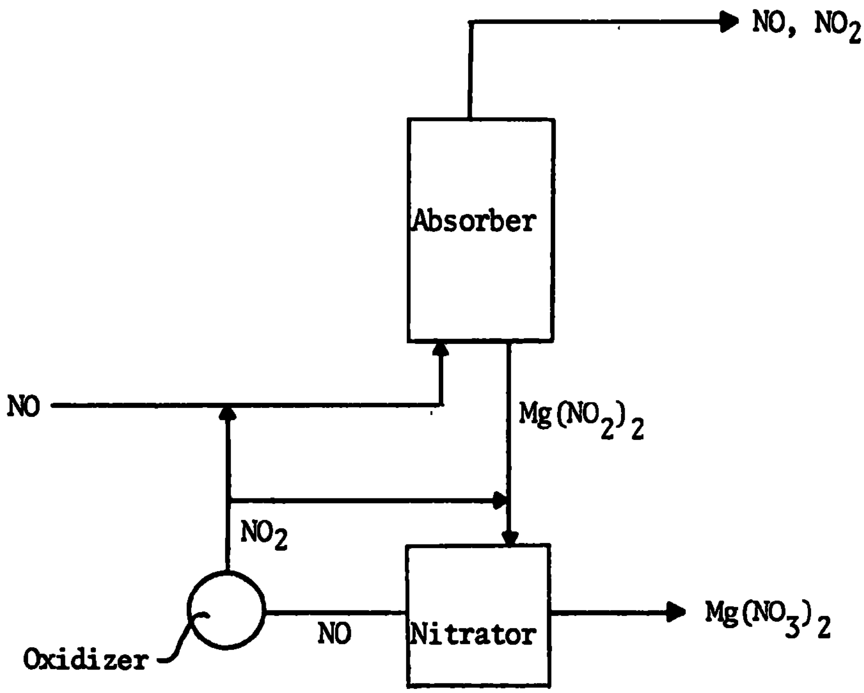

K+E SEMI-LOGARITHMIC 4 CYCLES X 60 DIVISIONS KEUFFEL & ESSER CO. 46 5893 MADE IN U.S.A.
FIGURE 5.2. PREDICTED NOX ABSORPTION IN TEST APPARATUS
Gas-Phase Diffusion Limiting
Gas-Phase Reaction Rate Limiting
kf atm-2 sec-1
59.4 x 10^4
29.2 x 10^4
14.6 x 10^4
7.3 x 10^4
3.65 x 10^4
1.825 x 10^4
Total Height = 4 ft
Temp. = 130°F (saturated to H2O)
Initial NO: 600 ppm
Initial NO2: 600 ppm
Initial HNO2: 84 ppm
Minimum Self Sustaining Absorption Rate
Maximum Probable for This Apparatus
Apparent MgO-NOX Range
NT ≜ -ℓn (1-E)
kga, lb moles/hr ft3
1.0
10.0
100.0
1000.0
0
1
2
3
4
5

FIGURE 5.3. PROCESS FLOW SCHEMATIC



Absorber: $NO + NO_2 + MgO \rightarrow Mg(NO_2)_2$

Nitrator: $3Mg(NO_2)_2 + 2H_2O \rightarrow 4NO + Mg(NO_3)_2 + 2Mg(OH)_2$

Absorber Efficiency	75*	80	85	90	95	99
Process Efficiency	50	60	70	80	90	98

* Minimum acceptable performance for self sustaining NO_2 supply.

6.0 CONCLUSIONS

1. NO_X absorption with equimolar concentration of NO and NO_2 into MgO slurry is unfeasible in the apparatus tested. It is probably unfeasible in any practical gas-slurry contacting apparatus.
2. NO_X absorption into soluble alkalis may be feasible and would best be done in packed towers.

7.0 RECOMMENDATIONS

1. MgO slurry should be removed from those bases being considered for aqueous NO_x absorption.
2. Work should continue on the feasibility evaluation of soluble bases for this system.

jlz

Submitted by: W. Downs/jlz
W. Downs

Approved by: H. P. Markant
H. P. Markant

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4. Ibid., p. 3-5 through 3-6.

5. S. S. Strom, "Catalytic Reduction of Nitrogen Dioxide with Ammonia," MS Thesis, University of Cincinnati, June, 1966, pp. 18-22.

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10. L. G. Wayne and D. M. Yost, J. Chem. Phys. 18, pp. 767-768, 1950.

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APPENDIX A

DETERMINATION OF NO_X: SALTZMAN METHOD

APPENDIX A

DETERMINATION OF NO_x: SALTZMAN METHOD

Introduction

The Saltzman method is intended for the manual determination of nitrogen dioxide in the atmosphere in the range of a few parts per billion (ppb) to about 5 ppm by changing the sample size, though the range can be increased to about 10,000 ppm. This method is also applicable to the determination of nitric oxide after it is oxidized to nitrogen dioxide. The nitrogen dioxide is absorbed in Griess-Saltzman reagent. A stable pink color is produced within 15 minutes and may be read visually or in an appropriate instrument. Only slight interfering effects occur from other gases.

Reagents

All reagents are made from analytical-grade chemicals in nitrite-free water prepared, if necessary, by redistilling distilled water in an all-glass still after adding a crystal of potassium permanganate and barium hydroxide. They are stable for several months if kept well stoppered in brown bottles in a refrigerator. The absorbing reagent should be allowed to warm to room temperature before use.

N-(1-Naphthyl) - Ethylenediamine Dihydrochloride, 0.1%

Dissolve 0.1 g of the reagent in 100 ml of water. This is a stock solution.

Sulfanilic Acid, 0.5%

Dissolve 5 g of sulfanilic acid in almost a liter of water containing 140 ml of glacial acetic acid. Gentle heating is permissible, if desired, to speed up the process. Cool and dilute to 1 liter with water.

Absorbing Reagent

Add 10 ml of the N-ethylenediamine dihydrochloride stock solution to a 500-ml volumetric flask and dilute to mark with the 0.5% sulfanilic acid. Mix just before use and discard at end of each day!

Standard Sodium Nitrite Solution, 0.0203 g/Liter

One ml of this working solution produces a color equivalent to that of 10 ml of nitrogen dioxide (10 ppm in 1 liter of air at 760 mm of mercury and 25°C). Prepare fresh just before use by dilution from a stronger stock solution containing 2.03 g of the reagent grade granular solid (drying is unnecessary) per liter. The stock solution should be stable for 90 days.

Apparatus

Spectrophotometer or Colorimeter

A laboratory instrument suitable for measuring the pink color at 550 mm, with stoppered tubes or cuvettes, is recommended.

10 or 20 ml Gas Tight Syringe

Hamilton type, for measuring gas samples.

100-ml Serum Bottle

Needle-puncture rubber stoppers, sleeve type, for serum bottles.

Analytical Procedure for Nitrogen Dioxide

Sampling Procedure

Pipet exactly 10 ml of absorbing reagent into a serum bottle and stopper bottle with rubber stopper. Inject 10 ml of the sample gas with the syringe and shake bottle vigorously. If the gas sample has an expected concentration of about 500 ppm, a 10-ml gas sample will yield an absorbance very near the standard. If the concentration is higher, use a smaller sample proportionally. If the gas sample temperature and pressure deviate greatly from 25°C and 760 mm Hg, measure and record the values.

Determination

After collection and absorption of the sample a pink color appears. Color development is complete within 15 minutes at ordinary temperatures. Transfer to cuvettes and read in a spectrophotometer at 550 mm using unexposed absorbing reagent as a blank. Colors may be preserved, if well stoppered, with only 3 to 4% loss in absorbance per day; however, if strong oxidizing or reducing gases are present in the sample in concentrations considerably exceeding that of the nitrogen dioxide, the absorbance should be determined as soon as possible to minimize any bleaching.

Standardization

Add graduated amounts of the working standard sodium nitrite solution up to 1 ml (measured accurately in a graduated pipet or small buret) to a series of the serum bottle containing 10 ml of the absorbing reagent. Mix, allow 15 minutes for complete color development, and read the absorbance.

APPENDIX B

COMPUTER OUTPUT

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 1-C DATE 9-11-71 TIME OF DAY 1530

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	454.	160.0	------	-----	-----	-------	0.016	74.8	447.	8.1
SECONDARY AIR	4595.	690.0	------	-----	-----	-------	0.016	75.6	4522.	6.3
FURNACE EXIT	5452.	680.0	1007.6	*****	*****	*******	0.059	116.9	5150.	2.6
PART.SCRB.INLET	5452.	565.0	******	*****	*****	*******	0.059	116.9	-----	2.7
PART.CYC.EXIT	3274.	148.0	1138.6	*****	*****	*******	0.159	147.9	2825.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3274.	150.0	******	*****	*****	*******	0.159	147.9	-----	-8.1
FLOATING BED EX	3686.	0.0	******	*****	*****	*******	0.196	153.4	-----	-16.3
P.P. EXIT ORIF.	3686.	138.0	10.3	*****	125.	*******	0.196	153.4	3081.	-16.3

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	142.0	0.0
RECIRCULATED LIQ.	142.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.1	92.0	3.1
PRODUCT LIQ.	*****	*****	142.0	0.0
REC.(SPRAY NOZ)	*****	*****	142.0	520.0
REC.(FLOW NOZ.)		*****		355.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.535E 07
% FUEL AS COAL	96.5
COAL FLOW RATE,#/HR	423.7
NAT.GAS FLOW,#/HR	8.6
% EXCESS AIR	14.8
OXYGEN,%DRY,MEAS.	3.10
CO2,%DRY-CALC.	15.39
HUMIDITY,#/# - CALC.	0.059

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	-13.01	******	99.09
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	91.8	******	6.3
LIQ/GAS,GAL/MCF	21.7	******	52.6
LIQ/GAS,#/#	3.0	******	5.8
PRES.DROP,IN.WG	2.7	******	5.3

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 30.0
SULFITE/SO2-MOL/MOL = 27.98
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.10
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 1-C   DATE 9-11-71   TIME OF DAY 1530

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.68	------	31.36	284.0	5142.
OUTPUT,#/HR	5.41	------	******	302.4	5150.
PART.SCRUBBER					
INPUT,#/HR	5.41	------	******	345.	5150.
OUTPUT,#/HR	3.35	------	******	449.	2825.
SO2 ABSORBERS					
INPUT,#/HR	3.35	7.53	******	658.	2825.
OUTPUT,#/HR	0.03	******	******	605.	3081.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.477223
HYDROGEN	0.620751
OXYGEN	1.393074
NITROGEN	5.046655
SULFUR	0.009072

FEED RATE,#/SEC= 1.50

ENTHALPY,BTU/# = -4412.

*SO2 ABSORBERS-PRODUCT COMP.	GM SO2/100ML	GM-MOLE/LITER	GRAM/100ML
TOTAL,	4.12	0.6440	------
COMBINED	4.12	0.6440	------
FREE	0.0	0.0	------
MONO(TOTAL)	4.12	0.6440	------
MONO(DISSOLVED)	0.96	0.1500	1.560
MONO(SOLID)	3.16	0.4940	10.473
BISULFITE	0.0	0.0	0.0
MGO	1.23	0.1929	0.771
SULFATE	*****	******	******
MAGNESIUM	5.36	0.8369	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	18.457

MAKEUP MGO COMPOSITION
- SLURRY CONC.- GM MGO/100ML = 6.75
- MGO PRESLAKED, NO=0, YES=1 . 0
- % SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES
- ACID STRENGTH, PH = 8.00
- SP.GRAVITY,HYDROM. = 1.0700

PARTICULATE SCRUBBER PRODUCT
- ACID STRENGTH , PH = 5.40
- FLYASH CONC. GM/100ML = 6.50

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*
*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 1-C   DATE 9-11-71   TIME OF DAY 1530

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5452.	680.0	1007.6	******	******	870.3	0.059	116.9	2.6
FLOAT.BED EX	3686.	138.0	10.3	124.8	******	902.0	0.196	153.4	-16.3
NOX SCRUB IN	3508.	176.0	10.3	233.4	******	686.0	0.196	153.4	2.7
NOX SCRUB EX	3554.	136.0	6.0	209.1	******	635.2	0.212	157.4	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	1.71
MAKEUP MGO	60.0	0.76
PRODUCT LIQ.	138.0	3.10
RECIRC. LIQ.	138.0	1250.

SCRUB.PERFORMANCE	
SO2 ABSORB.	41.70
NOX ABSORP.	10.45
NOX1 ABSORP	******
NOX2 ABSORP	7.41
GAS VEL.FPS	1.8
L/G,GAL/MCF	147.0
L/G,#/#	21.4
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	2.850
MGSO3(SOLID),M	0.0094
MGSO3(TOTAL),M	0.0097
MGSO4,MOLAR	0.0075
MG(NO2)2, MOLAR	0.0270
MG(NO3)2, MOLAR	0.0023
TSS,GM/100ML	11.677
NITRITE/NITRATE	11.739

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.0
NO2/NO(PDS BASIS)	0.87
NO2/NO(FC & ROTO)	0.0

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.03	0.0	723.8	0.31
OUTPUT,#/HR	0.12	3.39	624.3	0.43

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 0.0

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	9.30
CONDUCT.MICROMHOS	0.
SPECIFIC GRAVITY	0.0

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 2-A   DATE 9-15-71   TIME OF DAY 1745

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	487.	110.0	------	-----	-----	-------	0.014	71.8	480.	13.5
SECONDARY AIR	4523.	685.0	------	-----	-----	-------	0.017	76.4	4449.	4.0
FURNACE EXIT	5401.	640.0	1862.4	*****	*****	*******	0.058	116.3	5104.	0.0
PART.SCRB.INLET	5401.	570.0	******	*****	*****	*******	0.058	116.3	-----	2.7
PART.CYC.EXIT	3494.	143.0	1720.0	*****	*****	*******	0.161	148.2	3010.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3494.	143.0	******	*****	*****	*******	0.161	148.2	-----	-6.8
FLOATING BED EX	3847.	0.0	******	*****	*****	*******	0.191	152.8	-----	-13.5
P.P. EXIT ORIF.	3847.	135.0	3.5	*****	421.	*******	0.191	152.8	3230.	-13.5

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	142.0	0.0
RECIRCULATED LIQ.	142.0	20.02

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.8
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	141.0	0.0
REC.(SPRAY NOZ)	*****	*****	141.0	0.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.519E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	410.3
NAT.GAS FLOW,#/HR	8.8
% EXCESS AIR	16.7
OXYGEN,%DRY,MEAS.	3.50
CO2,%DRY-CALC.	15.03
HUMIDITY,#/# - CALC.	0.058

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	7.65	******	99.79
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	97.5	******	6.6
LIQ/GAS,GAL/MCF	20.7	******	54.3
LIQ/GAS,#/#	2.9	******	5.9
PRES.DROP,IN.WG	3.0	******	4.6

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 41.4
SULFITE/SO2-MOL/MOL = 20.86
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.50
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 2-A   DATE 9-15-71   TIME OF DAY 1745

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.18	------	30.36	278.1	5097.
OUTPUT,#/HR	9.93	------	******	297.1	5104.
PART.SCRUBBER					
INPUT,#/HR	9.93	------	******	360.	5104.
OUTPUT,#/HR	5.41	------	******	484.	3010.
SO2 ABSORBERS					
INPUT,#/HR	5.41	7.72	******	712.	3010.
OUTPUT,#/HR	0.01	******	******	617.	3230.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.467256
HYDROGEN	0.595881
OXYGEN	1.394189
NITROGEN	5.055843
SULFUR	0.008870

FEED RATE,#/SEC= 1.49

ENTHALPY,BTU/# = -4636.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.40	0.3755	------
COMBINED	2.40	0.3755	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.40	0.3755	------
MONO(DISSOLVED)	1.06	0.1656	1.722
MONO(SOLID)	1.34	0.2099	4.449
BISULFITE	0.0	0.0	0.0
MGO	4.56	0.7131	2.852
SULFATE	*****	******	******
MAGNESIUM	6.97	1.0886	------
FLYASH	-----	------	******
SOLIDS-MG	-----	------	20.411

MAKEUP MGO COMPOSITION
SLURRY CONC.- GM MGO/100ML = 6.70
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES
ACID STRENGTH, PH = 8.10
SP.GRAVITY,HYDROM. = 1.0750

PARTICULATE SCRUBBER PRODUCT
ACID STRENGTH , PH = 5.55
FLYASH CONC. GM/100ML = 5.50

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 2-A   .DATE 9-15-71   TIME OF DAY 1745

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5401.	640.0	1862.4	******	******	485.8	0.058	116.3	0.0
FLOAT.BED EX	3847.	135.0	3.5	420.7	******	485.8	0.191	152.8	-13.5
NOX SCRUB IN	3913.	136.0	******	1122.1	876.9	803.4	0.191	152.8	1.4
NOX SCRUB EX	3924.	128.0	******	901.3	******	308.3	0.194	154.7	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	133.0	2.35
RECIRC. LIQ.	133.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.09
NO2/NO(PDS BASIS)	1.67
NO2/NO(FC & ROTO)	2.29

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	19.67
NOX1 ABSORP	******
NOX2 ABSORP	61.63
GAS VEL.FPS	1.9
L/G,GAL/MCF	140.5
L/G,#/#	19.2
PRES.DROP,WG	0.0

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	1.787
MGSO3(SOLID),M	0.0156
MGSO3(TOTAL),M	0.0157
MGSO4,MOLAR	0.0066
MG(NO2)2, MOLAR	0.0055
MG(NO3)2, MOLAR	0.0103
TSS,GM/100ML	10.677
NITRITE/NITRATE	0.534

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.01	0.0	796.2	1.68
OUTPUT,#/HR	0.10	1.64	640.5	1.42

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 0.0

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	7.90
CONDUCT.MICROMHOS	5170.
SPECIFIC GRAVITY	1.018

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 3-E   DATE 9-15-71   TIME OF DAY 2000

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	487.	110.0	------	-----	-----	-------	0.015	73.8	480.	13.5
SECONDARY AIR	5128.	672.5	------	-----	-----	-------	0.014	71.2	5057.	4.7
FURNACE EXIT	6055.	650.0	1649.6	*****	*****	*******	0.056	114.9	5736.	0.0
PART.SCRB.INLET	6055.	540.0	******	*****	*****	*******	0.056	114.9	-----	2.7
PART.CYC.EXIT	3397.	144.0	******	*****	*****	*******	0.150	146.0	2954.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3397.	146.0	******	*****	*****	*******	0.150	146.0	-----	-6.8
FLOATING BED EX	3761.	0.0	******	*****	*****	*******	0.181	151.2	-----	-13.5
P.P. EXIT ORIF.	3761.	136.0	9.4	*****	*****	*******	0.181	151.2	3185.	-13.5

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	143.0	0.0
RECIRCULATED LIQ.	143.0	20.02

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.8
MAKEUP MGO SL.	*****	2.8	0.0	2.8
PRODUCT LIQ.	*****	*****	140.0	0.0
REC.(SPRAY NOZ)	*****	*****	140.0	0.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.583E 07
% FUEL AS COAL	96.6
COAL FLOW RATE,#/HR	462.8
NAT.GAS FLOW,#/HR	8.8
% EXCESS AIR	16.7
OXYGEN,%DRY,MEAS.	3.50
CO2,%DRY-CALC.	15.05
HUMIDITY,#/# - CALC.	0.056

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	******	******	******
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	94.4	******	6.4
LIQ/GAS,GAL/MCF	21.4	******	55.9
LIQ/GAS,#/#	2.9	******	6.1
PRES.DROP,IN.WG	3.0	******	5.5

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.50
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 3-E DATE 9-15-71 TIME OF DAY 2000

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	17.12	------	34.24	300.3	5726.
OUTPUT,#/HR	9.88	------	******	319.3	5736.
PART.SCRUBBER					
INPUT,#/HR	9.88	------	******	382.	5736.
OUTPUT,#/HR	******	------	******	442.	2954.
SO2 ABSORBERS					
INPUT,#/HR	******	6.25	******	649.	2954.
OUTPUT,#/HR	0.03	******	******	577.	3185.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.467918
HYDROGEN	0.603335
OXYGEN	1.394246
NITROGEN	5.055199
SULFUR	0.008905

FEED RATE,#/SEC= 1.67

ENTHALPY,BTU/# = -3592.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	3.13	0.4892	------
COMBINED	3.13	0.4892	------
FREE	0.0	0.0	------
MONO(TOTAL)	3.13	0.4892	------
MONO(DISSOLVED)	1.18	0.1844	1.917
MONO(SOLID)	1.95	0.3049	6.463
BISULFITE	0.0	0.0	0.0
MGO	4.28	0.6695	2.678
SULFATE	*****	******	******
MAGNESIUM	7.42	1.1587	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	19.612

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 6.20

MGO PRESLAKED, NO=0, YES=1 0

% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.05

SP.GRAVITY,HYDROM. = 1.0780

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 5.50

FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 3-E   DATE 9-15-71   TIME OF DAY 2000

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	6055.	650.0	1649.6	******	******	485.6	0.056	114.9	0.0
FLOAT.BED EX	3761.	136.0	9.4	******	******	504.3	0.181	151.2	-13.5
NOX SCRUB IN	3748.	162.0	******	969.3	930.3	644.4	0.181	151.2	1.4
NOX SCRUB EX	3781.	130.0	******	1180.9	986.7	551.0	0.192	154.3	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	134.0	2.35
RECIRC. LIQ.	134.0	850.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.09
NO2/NO(PDS BASIS)	*****
NO2/NO(FC & ROTO)	2.24

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	-21.83
NOX1 ABSORP	-6.07
NOX2 ABSORP	14.49
GAS VEL.FPS	1.8
L/G,GAL/MCF	96.1
L/G,#/#	13.6
PRES.DROP,WG	0.0

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	1.462
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0
MGSO4,MOLAR	0.0047
MG(NO2)2, MOLAR	0.0155
MG(NO3)2, MOLAR	0.0095
TSS,GM/100ML	8.398
NITRITF/NITRATE	1.632

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.03	2.88	738.5	1.40
OUTPUT,#/HR	0.02	1.34	610.2	1.81

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML=   4.00

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	8.05
CONDUCT.MICROMHOS	0.
SPECIFIC GRAVITY	1.018

NOX   = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 4-F   DATE 9-16-71   TIME OF DAY 1200

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	462.	110.0	------	-----	-----	-------	0.012	65.6	456.	-14.9
SECONDARY AIR	4454.	685.0	------	-----	-----	-------	0.010	60.6	4408.	5.0
FURNACE EXIT	5294.	540.0	1538.4	*****	*****	*******	0.052	112.8	5033.	0.0
PART.SCRB.INLET	5294.	450.0	******	*****	*****	*******	0.052	112.8	-----	2.7
PART.CYC.EXIT	3323.	142.0	1431.0	*****	*****	*******	0.125	140.6	2954.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3323.	143.0	******	*****	*****	*******	0.125	140.6	-----	-6.8
FLOATING BED EX	3604.	0.0	******	*****	*****	*******	0.156	146.4	-----	-17.6
P.P. EXIT ORIF.	3604.	128.0	10.3	*****	502.	*******	0.156	146.4	3118.	-17.6

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	135.0	0.0
RECIRCULATED LIQ.	135.0	20.02

	VENTURI ABSORBER		FBA	
GAS ABSORBER	TEMP,F	FLOW,#/M	TEMP,F	FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	133.0	0.0
REC.(SPRAY NOZ)	*****	*****	133.0	380.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.504E 07
% FUEL AS COAL	96.1
COAL FLOW RATE,#/HR	397.5
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.77
HUMIDITY,#/# - CALC.	0.052

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	6.98	******	99.28
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	90.4	******	6.1
LIQ/GAS,GAL/MCF	22.3	******	58.7
LIQ/GAS,#/#	3.0	******	6.3
PRES.DROP,IN.WG	2.3	******	12.8

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3 = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 31.9
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.80
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 4-F   DATE 9-16-71   TIME OF DAY 1200

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	14.71	------	29.42	242.5	5026.
OUTPUT,#/HR	8.09	------	******	261.6	5033.
PART.SCRUBBER					
INPUT,#/HR	8.09	------	******	324.	5033.
OUTPUT,#/HR	4.42	------	******	370.	2954.
SO2 ABSORBERS					
INPUT,#/HR	4.42	7.14	******	586.	2954.
OUTPUT,#/HR	0.03	******	******	486.	3118.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.459826
HYDROGEN	0.570051
OXYGEN	1.395035
NITROGEN	5.062690
SULFUR	0.008723

FEED RATE,#/SEC= 1.46

ENTHALPY,BTU/# = -1477.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	1.45	0.2263	------
COMBINED	1.45	0.2263	------
FREE	0.0	0.0	------
MONO(TOTAL)	1.45	0.2263	------
MONO(DISSOLVED)	*****	******	******
MONO(SOLID)	*****	******	******
BISULFITE	*****	******	******
MGO	1.71	0.2672	1.069
SULFATE	*****	******	******
MAGNESIUM	3.16	0.4934	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	1.690

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 6.20
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 7.80
SP.GRAVITY,HYDROM. = 1.0200

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 6.10
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 4-F DATE 9-16-71 TIME OF DAY 1200

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5294.	540.0	1538.4	******	******	561.9	0.052	112.8	0.0
FLOAT.BED EX	3604.	128.0	10.3	502.4	******	486.9	0.156	146.4	-17.6
NOX SCRUB IN	3541.	160.0	******	759.5	613.9	580.6	0.156	146.4	1.4
NOX SCRUB EX	3581.	122.0	******	855.0	751.1	299.7	0.169	150.7	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.71
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	124.0	2.95
RECIRC. LIQ.	124.0	500.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.06
NO2/NO(PDS BASIS)	0.51
NO2/NO(FC & ROTO)	1.55

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-12.57
NOX1 ABSORP	-22.35
NOX2 ABSORP	48.39
GAS VEL.FPS	1.7
L/G,GAL/MCF	61.0
L/G,#/#	8.5
PRES.DROP,WG	0.0

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	3.031
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0008
MGSO4,MOLAR	0.0076
MG(NO2)2, MOLAR	0.0054
MG(NO3)2, MOLAR	0.0014
TSS,GM/100ML	7.519
NITRITE/NITRATF	3.857

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.03	2.88	635.5	1.06
OUTPUT,#/HR	0.05	3.28	520.3	1.23

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 4.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	9.20
CONDUCT.MICROMHOS	2280.
SPECIFIC GRAVITY	1.015

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 5-K   DATE 9-16-71   TIME OF DAY 1530

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	487.	115.0	------	-----	-----	-------	0.015	74.2	480.	14.9
SECONDARY AIR	5146.	687.5	------	-----	-----	-------	0.011	64.9	5089.	5.3
FURNACE EXIT	6073.	600.0	******	*****	*****	*******	0.053	113.5	5767.	0.0
PART.SCRB.INLET	6073.	510.0	******	*****	*****	*******	0.053	113.5	-----	1.4
PART.CYC.EXIT	3188.	142.0	******	*****	*****	*******	0.140	143.7	2797.	-9.5
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3188.	140.0	******	*****	*****	*******	0.140	143.7	-----	-10.8
FLOATING BED EX	3409.	0.0	******	*****	*****	*******	0.173	150.1	-----	-12.2
P.P. EXIT ORIF.	3409.	128.0	******	*****	589.	*******	0.173	150.1	2907.	-12.2

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	132.0	0.0
RECIRCULATED LIQ.	132.0	20.02

	VENTURI ABSORBER		FBA	
GAS ABSORBER	TEMP,F	FLOW,#/M	TEMP,F	FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.0
MAKEUP MGO SL.	*****	2.8	80.0	2.8
PRODUCT LIQ.	*****	*****	132.0	0.0
REC.(SPRAY NOZ)	*****	*****	132.0	0.0
REC.(FLOW NOZ.)		*****		367.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.583E 07
% FUEL AS COAL	96.6
COAL FLOW RATE,#/HR	462.7
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	17.1
OXYGEN,%DRY,MEAS.	3.60
CO2,%DRY-CALC.	14.96
HUMIDITY,#/# - CALC.	0.053

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	******	******	******
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	88.0	******	5.7
LIQ/GAS,GAL/MCF	22.9	******	60.3
LIQ/GAS,#/#	3.1	******	6.5
PRES.DROP,IN.WG	4.5	******	5.5

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER		FLOATING BED ABSORBER	
KGA,#MOLE/HR-FT3,	******	KGA,#MOLE/HR-FT3	******
SULFITE/SO2-MOL/MOL	******	SULFITE/SO2-MOL/MOL	******
SUMP RESID.TIME,MIN	******	SUMP RESID.TIME,MIN	******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.60
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 5-K   DATE 9-16-71   TIME OF DAY 1530

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	17.12	------	34.24	286.7	5758.
OUTPUT,#/HR	******	------	******	305.8	5767.
PART.SCRUBBER					
INPUT,#/HR	******	------	******	306.	5767.
OUTPUT,#/HR	******	------	******	391.	2797.
SO2 ABSORBERS					
INPUT,#/HR	******	6.25	******	548.	2797.
OUTPUT,#/HR	******	******	******	502.	2907.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.465489
HYDROGEN	0.601821
OXYGEN	1.394532
NITROGEN	5.057435
SULFUR	0.008858

FEED RATE,#/SEC= 1.68

ENTHALPY,BTU/# = -1896.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	1.50	0.2350	------
COMBINED	1.50	0.2350	------
FREE	0.0	0.0	------
MONO(TOTAL)	1.50	0.2350	------
MONO(DISSOLVED)	1.08	0.1687	1.755
MONO(SOLID)	0.42	0.0663	1.405
BISULFITE	0.0	0.0	0.0
MGO	1.10	0.1715	0.686
SULFATE	*****	******	******
MAGNESIUM	2.60	0.4065	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	3.442

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 6.20

MGO PRESLAKED, NO=0, YES=1 0

% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 7.85

SP.GRAVITY,HYDROM. = 1.0200

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 5.55

FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 5-K DATE 9-16-71 TIME OF DAY 1530

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	6073.	600.0	******	******	******	588.1	0.053	113.5	0.0
FLOAT.BED EX	3409.	128.0	******	589.4	******	559.6	0.173	150.1	-12.2
NOX SCRUB IN	3260.	162.0	******	671.3	901.6	777.8	0.173	150.1	1.4
NOX SCRUB EX	3291.	128.0	******	920.6	1226.1	398.4	0.184	153.2	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.48
MAKEUP MGO	60.0	1.20
PRODUCT LIQ.	132.0	1.70
RECIRC. LIQ.	132.0	680.

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-37.13
NOX1 ABSORP	-35.99
NOX2 ABSORP	48.78
GAS VEL.FPS	1.6
L/G,GAL/MCF	89.2
L/G,#/#	12.5
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	1.662
MGSO3(SOLID),M	0.0125
MGSO3(TOTAL),M	0.0133
MGSO4,MOLAR	0.0048
MG(NO2)2, MOLAR	0.0060
MG(NO3)2, MOLAR	0.0010
TSS,GM/100ML	16.373
NITRITE/NITRATE	6.000

NO2 FLOW DATA	
NO2 FLOWRATE,#/MIN	0.06
NO2/NO(PDS BASIS)	0.14
NO2/NO(FC & ROTO)	1.45

MATERIAL BALANCE	SULFUR	MAGNESIUM	WATER	NITROGEN **
NOX SCRUBBER				
INPUT,#/HR	*****	1.73	578.3	0.85
OUTPUT,#/HR	0.06	1.08	512.3	1.19

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 4.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	7.90
CONDUCT.MICROMHOS	3600.
SPECIFIC GRAVITY	1.018

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

IHC210I PROGRAM INTERRUPT(P) OLD PSW IS FF15000 F 82015C58

IHC210I PROGRAM INTERRUPT(P) OLD PSW IS FF15000 F 82015C68

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 6-L DATE 9-22-71 TIME OF DAY 1545

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	491.	110.0	------	-----	-----	-------	0.010	61.2	486.	13.5
SECONDARY AIR	5027.	708.8	------	-----	-----	-------	0.015	74.3	4951.	4.8
FURNACE EXIT	5947.	480.0	******	*****	*****	*******	0.056	115.6	5630.	0.0
PART.SCRB.INLET	5947.	410.0	******	*****	*****	*******	0.056	115.6	-----	2.7
PART.CYC.EXIT	3721.	134.0	******	*****	*****	*******	0.122	139.8	3316.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3721.	136.0	******	*****	*****	*******	0.122	139.8	-----	-8.1
FLOATING BED EX	4124.	0.0	******	*****	*****	*******	0.151	148.7	-----	13.5
P.P. EXIT ORIF.	4124.	125.0	1308.8	*****	*****	*******	0.151	148.7	3582.	13.5

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	136.0	0.0
RECIRCULATED LIQ.	136.0	20.02

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	1.0
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	132.0	0.0
REC.(SPRAY NOZ)	*****	*****	132.0	0.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.569E 07
% FUEL AS COAL	96.5
COAL FLOW RATE,#/HR	451.4
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	17.1
OXYGEN,%DRY,MEAS.	3.60
CO2,%DRY-CALC.	14.96
HUMIDITY,#/# - CALC.	0.056

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	******	******	******
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	99.6	******	6.4
LIQ/GAS,GAL/MCF	20.3	******	55.9
LIQ/GAS,#/#	2.7	******	5.5
PRES.DROP,IN.WG	3.3	******	3.3

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER		FLOATING BED ABSORBER	
KGA,#MOLE/HR-FT3 =	******	KGA,#MOLE/HR-FT3 =	******
SULFITE/SO2-MOL/MOL =	******	SULFITE/SO2-MOL/MOL =	******
SUMP RESID.TIME,MIN =	******	SUMP RESID.TIME,MIN =	******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.60
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 6-L DATE 9-22-71 TIME OF DAY 1545

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	16.70	------	33.40	297.6	5622.
OUTPUT,#/HR	******	------	******	316.8	5630.
PART.SCRUBBER					
INPUT,#/HR	******	------	******	379.	5630.
OUTPUT,#/HR	******	------	******	405.	3316.
SO2 ABSORBERS					
INPUT,#/HR	******	******	******	660.	3316.
OUTPUT,#/HR	******	******	******	541.	3582.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.465347
HYDROGEN	0.545518
OXYGEN	1.394520
NITROGEN	5.057571
SULFUR	0.008851

FEED RATE,#/SEC= 1.64

ENTHALPY,BTU/# = -3087.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	*****	******	------
COMBINED	*****	******	------
FREE	*****	******	------
MONO(TOTAL)	*****	******	------
MONO(DISSOLVED)	*****	******	******
MONO(SOLID)	*****	******	******
BISULFITE	*****	******	******
MGO	*****	******	******
SULFATE	*****	******	******
MAGNESIUM	*****	******	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	******

MAKEUP MGO COMPOSITION
SLURRY CONC.- GM MGO/100ML = ******
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES
ACID STRENGTH, PH = *****
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT
ACID STRENGTH , PH = *****
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

RUN NUMBER 6-L   DATE 9-22-71   TIME OF DAY 1545

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5947.	480.0	******	******	******	******	0.056	115.6	0.0
FLOAT.BED EX	4124.	125.0	1308.8	******	******	******	0.151	148.7	13.5
NOX SCRUB IN	3927.	164.0	1308.8	******	******	******	0.151	148.7	1.4
NOX SCRUB EX	3980.	120.0	22.8	******	******	******	0.167	150.4	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.48
MAKEUP MGO	60.0	3.40
PRODUCT LIQ.	124.0	4.25
RECIRC. LIQ.	124.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.0
NO2/NO(PDS BASIS)	*****
NO2/NO(FC & ROTO)	*****

SCRUB.PERFORMANCE	
SO2 ABSORB.	98.26
NOX ABSORP.	-37.13
NOX1 ABSORP	-35.99
NOX2 ABSORP	48.78
GAS VEL.FPS	1.9
L/G,GAL/MCF	137.7
L/G,#/#	19.1
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	-0.0
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0
MGSO4,MOLAR	0.0
MG(NO2)2, MOLAR	0.0
MG(NO3)2, MOLAR	0.0
TSS,GM/100ML	0.0
NITRITE/NITRATE	0.0

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	4.90	0.0	748.3	*****
OUTPUT,#/HR	0.08	0.0	572.8	*****

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 0.0

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	0.0
CONDUCT.MICROMHOS	0.
SPECIFIC GRAVITY	0.0

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 7-C DATE 9-23-71 TIME OF DAY 1130

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	491.	110.0	------	-----	-----	-------	0.012	67.8	485.	14.9
SECONDARY AIR	4608.	710.0	------	-----	-----	-------	0.012	66.5	4554.	5.3
FURNACE EXIT	5482.	560.0	1799.0	*****	*****	*******	0.052	113.0	5210.	-0.1
PART.SCRB.INLET	5482.	470.0	******	*****	*****	*******	0.052	113.0	-----	2.7
PART.CYC.EXIT	3546.	138.0	1614.5	*****	*****	*******	0.131	142.0	3136.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3546.	138.0	******	*****	*****	*******	0.131	142.0	-----	-6.8
FLOATING BED EX	3715.	0.0	******	*****	*****	*******	0.160	147.7	-----	-13.5
P.P. EXIT ORIF.	3715.	130.0	21.2	*****	563.	*******	0.160	147.7	3202.	-13.5

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	138.0	0.0
RECIRCULATED LIQ.	138.0	20.02

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.6	0.0	3.6
PRODUCT LIQ.	*****	*****	136.0	0.0
REC.(SPRAY NOZ)	*****	*****	136.0	0.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.510E 07
% FUEL AS COAL	96.1
COAL FLOW RATE,#/HR	402.6
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	20.0
OXYGEN,%DRY,MEAS.	4.20
CO2,%DRY-CALC.	14.42
HUMIDITY,#/# - CALC.	0.052

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	10.26	******	98.69
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	96.0	******	6.2
LIQ/GAS,GAL/MCF	21.0	******	57.5
LIQ/GAS,#/#	2.8	******	6.1
PRES.DROP,IN.WG	3.1	******	4.4

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 28.8
SULFITE/SO2-MOL/MOL = 32.06
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 4.20
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 7-C   DATE 9-23-71   TIME OF DAY 1130

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	14.90	------	29.80	253.1	5203.
OUTPUT,#/HR	9.81	------	******	272.3	5210.
PART.SCRUBBER					
INPUT,#/HR	9.81	------	******	335.	5210.
OUTPUT,#/HR	5.30	------	******	411.	3136.
SO2 ABSORBERS					
INPUT,#/HR	5.30	******	******	663.	3136.
OUTPUT,#/HR	0.07	******	******	513.	3202.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.450212
HYDROGEN	0.560047
OXYGEN	1.396197
NITROGEN	5.071530
SULFUR	0.008542

FEED RATE,#/SEC= 1.51

ENTHALPY,BTU/# = -1315.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	1.41	0.2209	------
COMBINED	1.41	0.2209	------
FREE	0.0	0.0	------
MONO(TOTAL)	1.41	0.2209	------
MONO(DISSOLVED)	1.52	0.2375	2.470
MONO(SOLID)	-0.11	-.0166	-0.353
BISULFITE	0.0	0.0	0.0
MGO	0.79	0.1230	0.492
SULFATE	*****	******	******
MAGNESIUM	2.20	0.3439	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	2.093

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = ******

MGO PRESLAKED, NO=0, YES=1 0

% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.10

SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 5.50

FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 7-C DATE 9-23-71 TIME OF DAY 1130

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5482.	560.0	1799.0	******	******	733.2	0.052	113.0	-0.1
FLOAT.BED EX	3715.	130.0	21.2	563.4	******	695.6	0.160	147.7	-13.5
NOX SCRUB IN	3772.	164.0	******	504.1	324.2	714.4	0.160	147.7	1.4
NOX SCRUB EX	3816.	128.0	8.3	550.4	311.1	629.8	0.174	151.6	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN	SCRUB.PERFORMANCE		SPRAY SLURRY ANALYSIS	
			SO2 ABSORB.	61.02		
MAKEUP WATER	60.0	0.81	NOX ABSORP.	-9.17	MGO,GM/100ML	0.587
MAKEUP MGO	60.0	1.05	NOX1 ABSORP	4.04	MGSO3(SOLID),M	0.0031
PRODUCT LIQ.	130.0	2.90	NOX2 ABSORP	11.84	MGSO3(TOTAL),M	0.0137
RECIRC. LIQ.	130.0	1250.	GAS VEL.FPS	1.8	MGSO4,MOLAR	0.0241
			L/G,GAL/MCF	142.2	MG(NO2)2, MOLAR	0.0096
NO2 FLOW DATA			L/G,#/#	19.9	MG(NO3)2, MOLAR	0.0000
NO2 FLOWRATE,#/MIN	0.0		PRES.DROP,WG	0.1	TSS,GM/100ML	3.326
NO2/NO(PDS BASIS)	-0.11				NITRITE/NITRATE	******
NO2/NO(FC & ROTO)	0.0					

MATERIAL BALANCE

	SULFUR	MAGNESIUM	WATER	NITROGEN**
NOX SCRUBBER				
INPUT,#/HR	0.07	1.51	629.7	0.75
OUTPUT,#/HR	0.24	0.81	567.6	0.87

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 4.00

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	8.15
CONDUCT.MICROMHOS	6870.
SPECIFIC GRAVITY	1.012

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 8-B   DATE 9-23-71   TIME OF DAY 1345

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	488.	115.0	------	-----	-----	-------	0.011	64.7	483.	14.9
SECONDARY AIR	4602.	710.0	------	-----	-----	-------	0.014	70.4	4541.	5.6
FURNACE EXIT	5485.	590.0	1688.7	*****	*****	*******	0.055	114.5	5200.	0.0
PART.SCRB.INLET	5485.	485.0	******	*****	*****	*******	0.055	114.5	-----	2.7
PART.CYC.EXIT	3535.	138.0	1557.1	*****	*****	*******	0.137	143.3	3109.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3535.	138.0	******	*****	*****	*******	0.137	143.3	-----	-8.1
FLOATING BED EX	3703.	0.0	******	*****	*****	*******	0.167	148.7	-----	-14.9
P.P. EXIT ORIF.	3703.	130.0	13.2	*****	580.	*******	0.167	148.7	3174.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	140.0	0.0
RECIRCULATED LIQ.	140.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	1.0
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	137.0	0.0
REC.(SPRAY NOZ)	*****	*****	137.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.523E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	413.5
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	17.6
OXYGEN,%DRY,MEAS.	3.70
CO2,%DRY-CALC.	14.86
HUMIDITY,#/# - CALC.	0.055

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	7.79	******	99.15
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	96.3	******	6.2
LIQ/GAS,GAL/MCF	20.7	******	58.1
LIQ/GAS,#/#	2.8	******	6.2
PRES.DROP,IN.WG	3.3	******	4.7

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 31.4
SULFITE/SO2-MOL/MOL = 25.08
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.70
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 8-B   DATE 9-23-71   TIME OF DAY 1345

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.30	------	30.60	265.5	5193.
OUTPUT,#/HR	9.18	------	******	284.7	5200.
PART.SCRUBBER					
INPUT,#/HR	9.18	------	******	321.	5200.
OUTPUT,#/HR	5.06	------	******	426.	3109.
SO2 ABSORBERS					
INPUT,#/HR	5.06	4.61	******	673.	3109.
OUTPUT,#/HR	0.04	******	******	529.	3174.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.462460
HYDROGEN	0.558342
OXYGEN	1.394766
NITROGEN	5.060255
SULFUR	0.008780

FEED RATE,#/SEC= 1.51

ENTHALPY,BTU/# = -2326.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.23	0.3480	------
COMBINED	2.23	0.3480	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.23	0.3480	------
MONO(DISSOLVED)	1.12	0.1750	1.820
MONO(SOLID)	1.11	0.1730	3.669
BISULFITE	0.0	0.0	0.0
MGO	0.85	0.1329	0.532
SULFATE	*****	******	******
MAGNESIUM	3.08	0.4809	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	2.640

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML	=	4.00
MGO PRESLAKED, NO=0, YES=1		0
% SLAKED TO MG(OH)2,MEAS.	=	******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH	=	8.05
SP.GRAVITY,HYDROM.	=	*******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH	=	6.35
FLYASH CONC. GM/100ML	=	*****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 8-B DATE 9-23-71 TIME OF DAY 1345

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5485.	590.0	1688.7	******	******	759.6	0.055	114.5	0.0
FLOAT.BED EX	3703.	130.0	13.2	580.4	******	873.6	0.167	148.7	-14.9
NOX SCRUB IN	3719.	164.0	******	906.0	802.1	******	0.167	148.7	1.4
NOX SCRUB EX	3759.	128.0	******	947.5	566.9	******	0.179	152.5	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	130.0	2.90
RECIRC. LIQ.	130.0	1250.

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-4.58
NOX1 ABSORP	29.33
NOX2 ABSORP	11.84
GAS VEL.FPS	1.8
L/G,GAL/MCF	143.8
L/G,#/#	20.2
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	0.762
MGSO3(SOLID),M	0.0062
MGSO3(TOTAL),M	0.0065
MGSO4,MOLAR	0.0192
MG(NO2)2, MOLAR	0.0098
MG(NO3)2, MOLAR	0.0015
TSS,GM/100ML	3.037
NITRITE/NITRATE	6.533

NO2 FLOW DATA	
NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	0.56
NO2/NO(FC & ROTO)	0.46

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN**
INPUT,#/HR	0.04	2.88	694.6	1.32
OUTPUT,#/HR	0.14	0.95	573.9	1.44

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 4.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.20
CONDUCT.MICROMHOS	6000.
SPECIFIC GRAVITY	1.005

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

IHC210I PROGRAM INTERRUPT(P) OLD PSW IS FF15000 F A2016364

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 9-D   DATE 9-23-71   TIME OF DAY 1500

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	486.	120.0	------	-----	-----	-------	0.012	66.0	481.	14.9
SECONDARY AIR	4587.	717.5	------	-----	-----	-------	0.012	67.4	4531.	5.7
FURNACE EXIT	5464.	590.0	698.0	*****	*****	*******	0.053	113.8	5187.	0.0
PART.SCRB.INLET	5464.	490.0	******	*****	*****	*******	0.053	113.8	-----	2.7
PART.CYC.EXIT	3543.	138.0	698.0	*****	*****	*******	0.137	143.5	3116.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3543.	138.0	******	*****	*****	*******	0.137	143.5	-----	-8.1
FLOATING BED EX	3705.	0.0	******	*****	*****	*******	0.166	148.7	-----	-14.9
P.P. EXIT ORIF.	3705.	130.0	4.2	*****	0.	*******	0.166	148.7	3177.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	138.0	0.0
RECIRCULATED LIQ.	138.0	20.02

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	137.0	0.0
REC.(SPRAY NOZ)	*****	*****	137.0	0.0
REC.(FLOW NOZ.)		*****		380.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.519E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	410.1
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.77
HUMIDITY,#/# - CALC.	0.053

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	-0.0	******	99.40
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	96.1	******	6.2
LIQ/GAS,GAL/MCF	21.0	******	57.3
LIQ/GAS,#/#	2.8	******	6.2
PRES.DROP,IN.WG	3.3	******	4.7

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 33.7
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.80
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 9-D   DATE 9-23-71   TIME OF DAY 1500

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.17	------	30.35	257.9	5180.
OUTPUT,#/HR	3.78	------	******	277.1	5187.
PART.SCRUBBER					
INPUT,#/HR	3.78	------	******	340.	5187.
OUTPUT,#/HR	2.27	------	******	426.	3116.
SO2 ABSORBERS					
INPUT,#/HR	2.27	******	******	654.	3116.
OUTPUT,#/HR	******	******	******	527.	3177.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.459998
HYDROGEN	0.561502
OXYGEN	1.395050
NITROGEN	5.062521
SULFUR	0.008732

FEED RATE,#/SEC= 1.51

ENTHALPY,BTU/# = -1499.

*

*SO2 ABSORBERS-PRODUCT COMP.	GM SO2/100ML	GM-MOLE/LITER	GRAM/100ML
TOTAL,	*****	******	------
COMBINED	*****	******	------
FREE	*****	******	------
MONO(TOTAL)	*****	******	------
MONO(DISSOLVED)	*****	******	******
MONO(SOLID)	*****	******	******
BISULFITE	*****	******	******
MGO	*****	******	******
SULFATE	*****	******	******
MAGNESIUM	*****	******	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	******

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = ******

MGO PRESLAKED, NO=0, YES=1 0

% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIFS

ACID STRENGTH, PH = *****

SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = *****

FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

RUN NUMBER 9-D DATE 9-23-71 TIME OF DAY 1500

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5464.	590.0	698.0	******	******	******	0.053	113.8	0.0
FLOAT.BED EX	3705.	130.0	4.2	0.0	******	******	0.166	148.7	-14.9
NOX SCRUB IN	3715.	166.0	******	1026.2	937.1	******	0.166	148.7	1.4
NOX SCRUB EX	3758.	128.0	******	717.5	857.8	773.6	0.179	152.6	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.30
PRODUCT LIQ.	130.0	3.20
RECIRC. LIQ.	130.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.06
NO2/NO(PDS BASIS)	*****
NO2/NO(FC & ROTO)	*****

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	30.08
NOX1 ABSORP	8.46
NOX2 ABSORP	11.84
GAS VEL.FPS	1.8
L/G,GAL/MCF	143.7
L/G,#/#	20.2
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	0.900
MGSO3(SOLID),M	0.0031
MGSO3(TOTAL),M	0.0037
MGSO4,MOLAR	0.0134
MG(NO2)2, MOLAR	0.0124
MG(NO3)2, MOLAR	0.0003
TSS,GM/100ML	3.373
NITRITE/NITRATE	41.333

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.01	3.31	709.9	1.50
OUTPUT,#/HR	0.11	1.17	575.0	1.11

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 4.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.20
CONDUCT.MICROMHOS	6080.
SPECIFIC GRAVITY	1.010

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 10-G   DATE 9-24-71   TIME OF DAY 1200

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	482.	110.0	------	-----	-----	-------	0.008	56.9	478.	14.9
SECONDARY AIR	4640.	690.0	------	-----	-----	-------	0.012	66.9	4585.	5.2
FURNACE EXIT	5516.	490.0	1783.4	*****	*****	*******	0.053	113.7	5239.	0.0
PART.SCRB.INLET	5516.	410.0	******	*****	*****	*******	0.053	113.7	-----	2.7
PART.CYC.EXIT	3639.	130.0	1595.7	*****	*****	*******	0.119	139.2	3251.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3639.	130.0	******	*****	*****	*******	0.119	139.2	-----	-8.1
FLOATING BED EX	3798.	0.0	******	*****	*****	*******	0.147	145.0	-----	-14.9
P.P. EXIT ORIF.	3798.	125.0	4.1	*****	609.	*******	0.147	145.0	3312.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	132.0	0.0
RECIRCULATED LIQ.	132.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.5	0.0	3.5
PRODUCT LIQ.	*****	*****	130.0	0.0
REC.(SPRAY NOZ)	*****	*****	130.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.524E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	414.1
NAT.GAS FLOW,#/HR	9.1
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.77
HUMIDITY,#/# - CALC.	0.053

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	10.53	******	99.74
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	96.3	******	6.3
LIQ/GAS,GAL/MCF	20.7	******	57.5
LIQ/GAS,#/#	2.7	******	6.1
PRES.DROP,IN.WG	3.5	******	5.2

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3,	= ******
SULFITE/SO2-MOL/MOL	= ******
SUMP RESID.TIME,MIN	= ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3	= 40.9
SULFITE/SO2-MOL/MOL	= 28.05
SUMP RESID.TIME,MIN	= ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.80
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 10-G DATE 9-24-71 TIME OF DAY 1200

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.32	------	30.64	257.6	5232.
OUTPUT,#/HR	9.77	------	******	277.2	5239.
PART.SCRUBBER					
INPUT,#/HR	9.77	------	******	340.	5239.
OUTPUT,#/HR	5.42	------	******	388.	3251.
SO2 ABSORBERS					
INPUT,#/HR	5.42	7.41	******	625.	3251.
OUTPUT,#/HR	0.01	******	******	486.	3312.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.459919
HYDROGEN	0.528744
OXYGEN	1.395043
NITROGEN	5.062600
SULFUR	0.008727

FEED RATE,#/SEC= 1.52

ENTHALPY,BTU/# = -1857.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	3.05	0.4764	------
COMBINED	3.05	0.4764	------
FREE	0.0	0.0	------
MONO(TOTAL)	3.05	0.4764	------
MONO(DISSOLVED)	1.34	0.2094	2.177
MONO(SOLID)	1.71	0.2670	5.660
BISULFITE	0.0	0.0	0.0
MGO	0.59	0.0921	0.368
SULFATE	*****	******	******
MAGNESIUM	3.64	0.5684	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	3.161

MAKEUP MGO COMPOSITION

SLURRY CONC.= GM MGO/100ML = 5.80
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 7.95
SP.GRAVITY,HYDROM. = 1.0200

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = *****
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 10-G   DATE 9-24-71   TIME OF DAY 1200

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5516.	490.0	1783.4	******	******	692.4	0.053	113.7	0.0
FLOAT.BED EX	3798.	125.0	4.1	608.8	******	645.6	0.147	145.0	-14.9
NOX SCRUB IN	3761.	160.0	******	766.0	680.8	729.9	0.147	145.0	1.4
NOX SCRUB EX	3807.	122.0	******	1709.5	491.6	655.0	0.161	149.4	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.90
PRODUCT LIQ.	123.0	4.00
RECIRC. LIQ.	123.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	0.26
NO2/NO(FC & ROTO)	0.65

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	******
NOX1 ABSORP	27.79
NOX2 ABSORP	10.26
GAS VEL.FPS	1.8
L/G,GAL/MCF	145.4
L/G,#/#	19.9
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	0.562
MGSO3(SOLID),M	0.0031
MGSO3(TOTAL),M	0.0035
MGSO4,MOLAR	0.0070
MG(NO2)2, MOLAR	0.0055
MG(NO3)2, MOLAR	0.0006
TSS,GM/100ML	1.576
NITRITE/NITRATE	9.167

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.01	5.22	695.0	1.15
OUTPUT,#/HR	0.08	0.91	530.8	2.60

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 5.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.25
CONDUCT.MICROMHOS	660.
SPECIFIC GRAVITY	1.020

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 11-H   DATE 9-24-71   TIME OF DAY 1330

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	480.	110.0	------	-----	-----	-------	0.009	58.4	476.	13.5
SECONDARY AIR	4702.	691.3	------	-----	-----	-------	0.014	72.0	4636.	5.7
FURNACE EXIT	5581.	540.0	1801.2	*****	*****	*******	0.055	114.8	5290.	-0.1
PART.SCRB.INLET	5581.	450.0	******	*****	*****	*******	0.055	114.8	-----	4.1
PART.CYC.EXIT	3548.	139.0	1465.8	*****	*****	*******	0.129	141.6	3143.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3548.	135.0	******	*****	*****	*******	0.129	141.6	-----	-8.1
FLOATING BED EX	3721.	0.0	******	*****	*****	*******	0.157	147.2	-----	-14.9
P.P. EXIT ORIF.	3721.	130.0	30.9	*****	470.	*******	0.157	147.2	3214.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	137.0	0.0
RECIRCULATED LIQ.	137.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	136.0	0.0
REC.(SPRAY NOZ)	*****	*****	136.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.529E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	418.3
NAT.GAS FLOW,#/HR	9.1
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.77
HUMIDITY,#/# - CALC.	0.055

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	18.62	******	97.89
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	96.0	******	6.2
LIQ/GAS,GAL/MCF	20.8	******	58.3
LIQ/GAS,#/#	2.8	******	6.2
PRES.DROP,IN.WG	5.7	******	5.6

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER		FLOATING BED ABSORBER	
KGA,#MOLE/HR-FT3,	= ******	KGA,#MOLE/HR-FT3	= 25.7
SULFITE/SO2-MOL/MOL	= ******	SULFITE/SO2-MOL/MOL	= 32.40
SUMP RESID.TIME,MIN	= ******	SUMP RESID.TIME,MIN	= ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.80
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 11-H   DATE 9-24-71   TIME OF DAY 1330

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.48	------	30.95	271.0	5283.
OUTPUT,#/HR	9.96	------	******	290.5	5290.
PART.SCRUBBER					
INPUT,#/HR	9.96	------	******	354.	5290.
OUTPUT,#/HR	4.82	------	******	406.	3143.
SO2 ABSORBERS					
INPUT,#/HR	4.82	6.68	******	622.	3143.
OUTPUT,#/HR	0.10	******	******	506.	3214.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.459979
HYDROGEN	0.533617
OXYGEN	1.395048
NITROGEN	5.062540
SULFUR	0.008731

FEED RATE,#/SEC= 1.54

ENTHALPY,BTU/# = -2870.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	4.06	0.6344	------
COMBINED	4.06	0.6344	------
FREE	0.0	0.0	------
MONO(TOTAL)	4.06	0.6344	------
MONO(DISSOLVED)	1.38	0.2156	2.242
MONO(SOLID)	2.68	0.4188	8.878
BISULFITE	0.0	0.0	0.0
MGO	1.25	0.1960	0.784
SULFATE	*****	******	******
MAGNESIUM	5.31	0.8303	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	11.655

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 5.80
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.00
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 6.70
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 11-H DATE 9-24-71 TIME OF DAY 1330

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5581.	540.0	1801.2	******	******	748.7	0.055	114.8	-0.1
FLOAT.BED EX	3721.	130.0	30.9	469.5	******	664.4	0.157	147.2	-14.9
NOX SCRUB IN	3688.	164.0	******	913.9	696.2	786.1	0.157	147.2	1.4
NOX SCRUB EX	3736.	126.0	******	274.1	509.7	505.3	0.172	151.5	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	4.15
PRODUCT LIQ.	128.0	4.80
RECIRC. LIQ.	128.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	0.95
NO2/NO(FC & ROTO)	0.65

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	70.00
NOX1 ABSORP	26.79
NOX2 ABSORP	35.71
GAS VEL.FPS	1.8
L/G,GAL/MCF	146.4
L/G,#/#	20.3
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	0.450
MGSO3(SOLID),M	0.0031
MGSO3(TOTAL),M	0.0033
MGSO4,MOLAR	0.0056
MG(NO2)2, MOLAR	0.0119
MG(NO3)2, MOLAR	0.0027
TSS,GM/100ML	1.409
NITRITE/NITRATE	4.407

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.10	7.47	787.0	1.33
OUTPUT,#/HR	0.08	0.94	554.0	0.52

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 5.00

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	8.05
CONDUCT.MICROMHOS	535.
SPECIFIC GRAVITY	1.050

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 12-A   DATE 9-24-71   TIME OF DAY 1430

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	481.	110.0	------	-----	-----	-------	0.010	62.7	476.	14.9
SECONDARY AIR	4704.	692.5	------	-----	-----	-------	0.014	72.0	4638.	5.8
FURNACE EXIT	5583.	560.0	1741.8	*****	*****	*******	0.055	114.9	5292.	0.0
PART.SCRB.INLET	5583.	460.0	******	*****	*****	*******	0.055	114.9	-----	2.7
PART.CYC.EXIT	3550.	138.0	1479.5	*****	*****	*******	0.132	142.3	3137.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3550.	135.0	******	*****	*****	*******	0.132	142.3	-----	-8.1
FLOATING BED EX	3713.	0.0	******	*****	*****	*******	0.160	147.7	-----	-14.9
P.P. EXIT ORIF.	3713.	132.0	30.9	*****	502.	*******	0.160	147.7	3201.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	138.0	0.0
RECIRCULATED LIQ.	138.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	136.0	0.0
REC.(SPRAY NOZ)	*****	*****	136.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.529E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	418.4
NAT.GAS FLOW,#/HR	9.1
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.77
HUMIDITY,#/# - CALC.	0.055

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	15.06	******	97.91
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	95.9	******	6.2
LIQ/GAS,GAL/MCF	20.8	******	58.4
LIQ/GAS,#/#	2.8	******	6.2
PRES.DROP,IN.WG	3.3	******	6.0

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, =	******
SULFITE/SO2-MOL/MOL =	******
SUMP RESID.TIME,MIN =	******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 =	25.7
SULFITE/SO2-MOL/MOL =	31.77
SUMP RESID.TIME,MIN =	******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.80
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 12-A DATE 9-24-71 TIME OF DAY 1430

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.48	------	30.96	271.7	5285.
OUTPUT,#/HR	9.63	------	******	291.3	5292.
PART.SCRUBBER					
INPUT,#/HR	9.63	------	******	354.	5292.
OUTPUT,#/HR	4.85	------	******	413.	3137.
SO2 ABSORBERS					
INPUT,#/HR	4.85	6.68	******	630.	3137.
OUTPUT,#/HR	0.10	******	******	512.	3201.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.459981
HYDROGEN	0.548169
OXYGEN	1.395048
NITROGEN	5.062539
SULFUR	0.008731

FEED RATE,#/SEC= 1.54

ENTHALPY,BTU/# = -2906.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	4.54	0.7089	------
COMBINED	4.54	0.7089	------
FREE	0.0	0.0	------
MONO(TOTAL)	4.54	0.7089	------
MONO(DISSOLVED)	1.36	0.2125	2.210
MONO(SOLID)	3.18	0.4964	10.523
BISULFITE	0.0	0.0	0.0
MGO	1.52	0.2375	0.950
SULFATE	*****	******	******
MAGNESIUM	6.06	0.9464	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	27.151

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 5.80

MGO PRESLAKED, NO=0, YES=1 0

% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 7.95

SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 6.50

FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 12-A   DATE 9-24-71   TIME OF DAY 1430

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5583.	560.0	1741.8	******	******	748.6	0.055	114.9	0.0
FLOAT.BED EX	3713.	132.0	30.9	501.6	******	655.0	0.160	147.7	-14.9
NOX SCRUB IN	3684.	165.0	******	******	442.0	842.2	0.160	147.7	1.4
NOX SCRUB EX	3730.	126.0	******	762.0	******	617.6	0.174	151.9	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	130.0	3.35
RECIRC. LIQ.	130.0	1250.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	*****
NO2/NO(FC & ROTO)	0.67

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	70.00
NOX1 ABSORP	******
NOX2 ABSORP	26.67
GAS VEL.FPS	1.8
L/G,GAL/MCF	146.2
L/G,#/#	20.4
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	0.512
MGSO3(SOLID),M	0.0031
MGSO3(TOTAL),M	0.0033
MGSO4,MOLAR	0.0049
MG(NO2)2, MOLAR	0.0121
MG(NO3)2, MOLAR	0.0028
TSS,GM/100ML	1.500
NITRITE/NITRATE	4.321

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.10	3.60	671.0	*****
OUTPUT,#/HR	0.05	0.73	557.2	1.19

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 5.00

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	7.95
CONDUCT.MICROMHOS	824.
SPECIFIC GRAVITY	1.010

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 13-A   DATE 9-27-71   TIME OF DAY 1600

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	468.	110.0	------	-----	-----	-------	0.017	76.9	460.	14.9
SECONDARY AIR	4822.	690.0	------	-----	-----	-------	0.017	76.2	4744.	5.7
FURNACE EXIT	5696.	570.0	1713.5	*****	*****	*******	0.058	116.1	5386.	-0.1
PART.SCRB.INLET	5696.	460.0	******	*****	*****	*******	0.058	116.1	-----	2.7
PART.CYC.EXIT	3381.	138.0	1116.7	*****	*****	*******	0.135	142.8	2980.	-6.8
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3381.	139.0	******	*****	*****	*******	0.135	142.8	-----	-10.8
FLOATING BED EX	3547.	0.0	******	*****	*****	*******	0.164	148.2	-----	-14.9
P.P. EXIT ORIF.	3547.	132.0	8.5	*****	581.	*******	0.164	148.2	3047.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	137.0	0.0
RECIRCULATED LIQ.	137.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.3	0.0	3.3
PRODUCT LIQ.	*****	*****	137.0	0.0
REC.(SPRAY NOZ)	*****	*****	137.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACF PERFORMANCE	
HEAT RELEASE,BTU/HR	0.539E 07
% FUEL AS COAL	96.4
COAL FLOW RATE,#/HR	426.4
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	18.1
OXYGEN,%DRY,MEAS.	3.80
CO2,%DRY-CALC.	14.78
HUMIDITY,#/# - CALC.	0.058

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	34.83	******	99.24
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	91.9	******	6.0
LIQ/GAS,GAL/MCF	21.7	******	60.6
LIQ/GAS,#/#	2.9	******	6.5
PRES.DROP,IN.WG	2.8	******	4.1

O2 ABSORPTION PARAMETERS

VENTURI ABSORBER		FLOATING BED ABSORBER	
KGA,#MOLE/HR-FT3,	= ******	KGA,#MOLE/HR-FT3	= 30.8
SULFITE/SO2-MOL/MOL	= ******	SULFITE/SO2-MOL/MOL	= 40.32
SUMP RESID.TIME,MIN	= ******	SUMP RESID.TIME,MIN	= ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.80
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 13-A DATE 9-27-71 TIME OF DAY 1600

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.78	------	31.55	291.0	5378.
OUTPUT,#/HR	9.65	------	******	310.1	5386.
PART.SCRUBBER					
INPUT,#/HR	9.65	------	******	373.	5386.
OUTPUT,#/HR	3.48	------	******	401.	2980.
SO2 ABSORBERS					
INPUT,#/HR	3.48	5.67	******	628.	2980.
OUTPUT,#/HR	0.03	******	******	500.	3047.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.460222
HYDROGEN	0.613882
OXYGEN	1.395070
NITROGEN	5.062304
SULFUR	0.008743

FEED RATE,#/SEC= 1.57

ENTHALPY,BTU/# = -4283.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	1.97	0.3080	------
COMBINED	1.97	0.3080	------
FREE	0.0	0.0	------
MONO(TOTAL)	1.97	0.3080	------
MONO(DISSOLVED)	1.24	0.1937	2.015
MONO(SOLID)	0.73	0.1143	2.423
BISULFITE	0.0	0.0	0.0
MGO	1.77	0.2760	1.104
SULFATE	*****	******	******
MAGNESIUM	3.74	0.5840	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	5.635

MAKEUP MGO COMPOSITION
SLURRY CONC.- GM MGO/100ML = 4.70
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES
ACID STRENGTH, PH = 8.10
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT
ACID STRENGTH , PH = 5.15
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 13-A   DATE 9-27-71   TIME OF DAY 1600

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5696.	570.0	1713.5	******	******	674.2	0.058	116.1	=0.1
FLOAT.BED EX	3547.	132.0	8.5	580.9	******	730.4	0.164	148.2	-14.9
NOX SCRUB IN	3466.	166.0	******	525.8	662.5	664.8	0.164	148.2	1.4
NOX SCRUB EX	3509.	128.0	******	580.3	256.4	725.7	0.179	152.3	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	132.0	3.35
RECIRC. LIQ.	132.0	1270.

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-10.36
NOX1 ABSORP	61.30
NOX2 ABSORP	-9.15
GAS VEL.FPS	1.7
L/G,GAL/MCF	156.2
L/G,#/#	22.0
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	0.975
MGSO3(SOLID),M	0.0312
MGSO3(TOTAL),M	0.0332
MGSO4,MOLAR	0.0292
MG(NO2)2, MOLAR	0.0106
MG(NO3)2, MOLAR	0.0018
TSS,GM/100ML	11.783
NITRITE/NITRATE	5.889

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	-0.09
NO2/NO(FC & ROTO)	0.63

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.03	4.18	650.0	0.72
OUTPUT,#/HR	0.40	1.54	535.0	0.86

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 5.80

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.15
CONDUCT.MICROMHOS	397.
SPECIFIC GRAVITY	1.025

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 14-I   DATE 9-27-71   TIME OF DAY 1700

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	474.	120.0	------	-----	-----	-------	0.016	76.1	467.	14.9
SECONDARY AIR	4575.	691.3	------	-----	-----	-------	0.017	77.0	4499.	6.0
FURNACE EXIT	5434.	590.0	1704.6	*****	*****	*******	0.058	116.2	5138.	0.0
PART.SCRB.INLET	5434.	490.0	******	*****	*****	*******	0.058	116.2	-----	4.1
PART.CYC.EXIT	3311.	139.0	1587.7	*****	*****	*******	0.142	144.3	2900.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3311.	140.0	******	*****	*****	*******	0.142	144.3	-----	-8.1
FLOATING BED EX	3480.	0.0	******	*****	*****	*******	0.171	149.4	-----	-16.3
P.P. EXIT ORIF.	3480.	133.0	2.0	*****	529.	*******	0.171	149.4	2971.	-16.3

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	138.0	0.0
RECIRCULATED LIQ.	138.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.6
MAKEUP MGO SL.	*****	3.3	0.0	3.3
PRODUCT LIQ.	*****	*****	138.0	0.0
REC.(SPRAY NOZ)	*****	*****	138.0	0.0
REC.(FLOW NOZ.)		*****		3.8

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.511E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	403.8
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	18.6
OXYGEN,%DRY,MEAS.	3.90
CO2,%DRY-CALC.	14.68
HUMIDITY,#/# - CALC.	0.058

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	6.86	******	99.88
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	90.8	******	5.9
LIQ/GAS,GAL/MCF	22.0	******	0.6
LIQ/GAS,#/#	3.0	******	0.1
PRES.DROP,IN.WG	2.5	******	-15.0

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 41.2
SULFITE/SO2-MOL/MOL = 0.23
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.90
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 14-I   DATE 9-27-71   TIME OF DAY 1700

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	14.94	------	29.88	277.8	5131.
OUTPUT,#/HR	9.16	------	******	296.9	5138.
PART.SCRUBBER					
INPUT,#/HR	9.16	------	******	360.	5138.
OUTPUT,#/HR	4.81	------	******	411.	2900.
SO2 ABSORBERS					
INPUT,#/HR	4.81	5.67	******	638.	2900.
OUTPUT,#/HR	0.01	******	******	509.	2971.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.457498
HYDROGEN	0.608727
OXYGEN	1.395331
NITROGEN	5.064827
SULFUR	0.008681

FEED RATE,#/SEC= 1.49

ENTHALPY,BTU/# = -4413.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.15	0.3359	------
COMBINED	2.15	0.3359	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.15	0.3359	------
MONO(DISSOLVED)	0.96	0.1500	1.560
MONO(SOLID)	1.19	0.1859	3.942
BISULFITE	0.0	0.0	0.0
MGO	3.44	0.5368	2.147
SULFATE	*****	******	******
MAGNESIUM	5.59	0.8728	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	11.272

MAKEUP MGO COMPOSITION
SLURRY CONC.- GM MGO/100ML = 4.70
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES
ACID STRENGTH, PH = 8.10
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT
ACID STRENGTH , PH = 5.30
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*
*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 14-I   DATE 9-27-71   TIME OF DAY 1700

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5434.	590.0	1704.6	******	******	648.7	0.058	116.2	0.0
FLOAT.BED EX	3480.	133.0	2.0	528.6	******	614.9	0.171	149.4	-16.3
NOX SCRUB IN	3460.	166.0	******	1310.9	689.1	******	0.171	149.4	1.4
NOX SCRUB EX	3502.	129.0	******	1076.8	492.4	******	0.186	153.5	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	1.20
PRODUCT LIQ.	133.0	3.00
RECIRC. LIQ.	133.0	1270.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.03
NO2/NO(PDS BASIS)	1.48
NO2/NO(FC & ROTO)	0.76

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	17.86
NOX1 ABSORP	28.55
NOX2 ABSORP	-9.15
GAS VEL.FPS	1.7
L/G,GAL/MCF	155.9
L/G,#/#	22.0
PRES.DROP,WG	0.1

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	3.350
MGSO3(SOLID),M	0.0031
MGSO3(TOTAL),M	0.0041
MGSO4,MOLAR	0.0185
MG(NO2)2, MOLAR	0.0115
MG(NO3)2, MOLAR	0.0020
TSS,GM/100ML	16.356
NITRITE/NITRATE	5.750

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.01	4.41	619.1	1.77
OUTPUT,#/HR	0.13	3.77	551.2	1.52

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 10.20

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	8.25
CONDUCT.MICROMHOS	310.
SPECIFIC GRAVITY	1.040

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 15-A   DATE 9-28-71   TIME OF DAY 1325

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	471.	130.0	------	-----	-----	-------	0.018	79.4	462.	14.9
SECONDARY AIR	4538.	687.5	------	-----	-----	-------	0.020	81.8	4450.	5.5
FURNACE EXIT	5396.	540.0	1675.5	*****	*****	*******	0.061	118.1	5085.	0.0
PART.SCRB.INLET	5396.	440.0	******	*****	*****	*******	0.061	118.1	-----	2.7
PART.CYC.EXIT	3432.	139.0	1369.9	*****	*****	*******	0.134	142.6	3027.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3432.	135.0	******	*****	*****	*******	0.134	142.6	-----	-8.1
FLOATING BED EX	3560.	0.0	******	*****	*****	*******	0.162	147.9	-----	-14.9
P.P. EXIT ORIF.	3560.	130.0	18.4	*****	547.	*******	0.162	147.9	3063.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	136.0	0.0
RECIRCULATED LIQ.	136.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.7
MAKEUP MGO SL.	*****	3.4	0.0	3.4
PRODUCT LIQ.	*****	*****	135.0	0.0
REC.(SPRAY NOZ)	*****	*****	135.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.514E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	406.4
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	17.1
OXYGEN,%DRY,MEAS.	3.60
CO2,%DRY-CALC.	14.94
HUMIDITY,#/# - CALC.	0.061

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	18.24	******	98.66
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	93.4	******	6.0
LIQ/GAS,GAL/MCF	21.4	******	60.6
LIQ/GAS,#/#	2.9	******	6.5
PRES.DROP,IN.WG	3.0	******	7.2

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = 27.4
SULFITE/SO2-MOL/MOL = 22.69
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.60
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 15-A   DATE 9-28-71   TIME OF DAY 1325

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.04	------	30.07	291.5	5078.
OUTPUT,#/HR	8.90	------	******	310.6	5085.
PART.SCRUBBER					
INPUT,#/HR	8.90	------	******	374.	5085.
OUTPUT,#/HR	4.33	------	******	404.	3027.
SO2 ABSORBERS					
INPUT,#/HR	4.33	5.63	******	641.	3027.
OUTPUT,#/HR	0.06	******	******	496.	3063.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.464768
HYDROGEN	0.634411
OXYGEN	1.394469
NITROGEN	5.058137
SULFUR	0.008820

FEED RATE,#/SEC= 1.48

ENTHALPY,BTU/# = -6030.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.88	0.4495	------
COMBINED	2.88	0.4495	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.88	0.4495	------
MONO(DISSOLVED)	0.86	0.1344	1.397
MONO(SOLID)	2.02	0.3151	6.680
BISULFITE	0.0	0.0	0.0
MGO	3.55	0.5552	2.221
SULFATE	*****	******	******
MAGNESIUM	6.43	1.0047	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	11.985

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 4.60
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.05
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = *****
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*
*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 15-A   DATE 9-28-71   TIME OF DAY 1325

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5396.	540.0	1675.5	******	******	785.5	0.061	118.1	0.0
FLOAT.BED EX	3560.	130.0	18.4	547.5	******	835.8	0.162	147.9	-14.9
NOX SCRUB IN	3518.	168.0	******	971.8	694.9	795.6	0.162	147.9	1.4
NOX SCRUB EX	3560.	128.0	******	1136.4	471.8	845.9	0.176	152.1	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	2.00
PRODUCT LIQ.	130.0	3.00
RECIRC. LIQ.	130.0	1260.

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-16.93
NOX1 ABSORP	32.10
NOX2 ABSORP	-6.33
GAS VEL.FPS	1.7
L/G,GAL/MCF	152.8
L/G,#/#	21.5
PRES.DROP,WG	0.2

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	-0.0
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0003
MGSO4,MOLAR	0.0061
MG(NO2)2, MOLAR	0.0082
MG(NO3)2, MOLAR	0.0012
TSS,GM/100ML	12.929
NITRITE/NITRATE	6.833

NO2 FLOW DATA	
NO2 FLOWRATE,#/MIN	0.04
NO2/NO(PDS BASIS)	0.78
NO2/NO(FC & ROTO)	0.59

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	** NITROGEN
INPUT,#/HR	0.06	4.46	651.8	1.34
OUTPUT,#/HR	0.04	0.07	536.5	1.62

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 6.20

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.10
CONDUCT.MICROMHOS	208.
SPECIFIC GRAVITY	1.040

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 16-K   DATE 9-28-71   TIME OF DAY 1500

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	471.	130.0	------	-----	-----	-------	0.019	80.3	462.	14.9
SECONDARY AIR	4532.	687.5	------	-----	-----	-------	0.019	79.9	4449.	6.1
FURNACE EXIT	5387.	570.0	1643.2	*****	*****	*******	0.060	117.5	5083.	0.0
PART.SCRB.INLET	5387.	460.0	******	*****	*****	*******	0.060	117.5	-----	2.7
PART.CYC.EXIT	2580.	139.0	******	*****	*****	*******	0.137	143.6	2269.	-5.4
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	2580.	135.0	******	*****	*****	*******	0.137	143.6	-----	-5.4
FLOATING BED EX	2759.	0.0	******	*****	*****	*******	0.166	148.6	-----	-14.9
P.P. EXIT ORIF.	2759.	128.0	14.2	*****	628.	*******	0.166	148.6	2367.	-14.9

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	135.0	0.0
RECIRCULATED LIQ.	135.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.8
MAKEUP MGO SL.	*****	3.5	0.0	3.5
PRODUCT LIQ.	*****	*****	133.0	0.0
REC.(SPRAY NOZ)	*****	*****	133.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.511E 07
% FUEL AS COAL	96.2
COAL FLOW RATE,#/HR	403.9
NAT.GAS FLOW,#/HR	8.9
% EXCESS AIR	17.6
OXYGEN,%DRY,MEAS.	3.70
CO2,%DRY-CALC.	14.86
HUMIDITY,#/# - CALC.	0.060

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	******	******	******
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	69.9	******	4.6
LIQ/GAS,GAL/MCF	28.5	******	78.0
LIQ/GAS,#/#	3.8	******	8.4
PRES.DROP,IN.WG	1.6	******	15.7

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER

KGA,#MOLE/HR-FT3, = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

FLOATING BED ABSORBER

KGA,#MOLE/HR-FT3 = ******
SULFITE/SO2-MOL/MOL = ******
SUMP RESID.TIME,MIN = ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L= ******
MOL% TOTAL SULF= *****
O2 AT FURN. EX.= 3.70
O2 AT ABSORB.IN= *****
O2 AT ABSORB.EX= *****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 16-K   DATE 9-28-71   TIME OF DAY 1500

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	14.94	------	29.89	285.6	5076.
OUTPUT,#/HR	8.73	------	******	304.7	5083.
PART.SCRUBBER					
INPUT,#/HR	8.73	------	******	368.	5083.
OUTPUT,#/HR	******	------	******	311.	2269.
SO2 ABSORBERS					
INPUT,#/HR	******	5.80	******	560.	2269.
OUTPUT,#/HR	0.04	******	******	392.	2367.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.462322
HYDROGEN	0.637765
OXYGEN	1.394753
NITROGEN	5.060390
SULFUR	0.008773

FEED RATE,#/SEC= 1.48

ENTHALPY,BTU/# = -5495.

*

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.91	0.4540	------
COMBINED	2.91	0.4540	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.91	0.4540	------
MONO(DISSOLVED)	-2.70	-.4219	-4.387
MONO(SOLID)	5.61	0.8759	18.569
BISULFITE	2.64	0.2062	3.836
MGO	3.81	0.5955	2.382
SULFATE	*****	******	******
MAGNESIUM	6.72	1.0495	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	11.253

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 4.60
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.10
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = *****
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 16-K   DATE 9-28-71   TIME OF DAY 1500

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5387.	570.0	1643.2	******	******	715.7	0.060	117.5	0.0
FLOAT.BED EX	2759.	128.0	14.2	627.7	******	403.2	0.166	148.6	-14.9
NOX SCRUB IN	2726.	166.0	******	866.3	642.5	846.8	0.166	148.6	1.4
NOX SCRUB EX	2763.	128.0	******	886.4	449.4	514.1	0.182	153.0	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	1.20
PRODUCT LIQ.	130.0	3.00
RECIRC. LIQ.	130.0	800.

SCRUB.PERFORMANCE	
SO2 ABSORB.	******
NOX ABSORP.	-2.32
NOX1 ABSORP	30.06
NOX2 ABSORP	39.29
GAS VEL.FPS	1.3
L/G,GAL/MCF	125.3
L/G,#/#	17.6
PRES.DROP,WG	0.2

SPRAY SLURRY ANALYSIS	
MGO,GM/100ML	-0.0
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0
MGSO4,MOLAR	0.0047
MG(NO2)2, MOLAR	0.0138
MG(NO3)2, MOLAR	0.0023
TSS,GM/100ML	9.047
NITRITE/NITRATE	6.000

NO2 FLOW DATA	
NO2 FLOWRATE,#/MIN	0.02
NO2/NO(PDS BASIS)	0.38
NO2/NO(FC & ROTO)	0.92

MATERIAL BALANCE	SULFUR	MAGNESIUM	WATER	** NITROGEN
NOX SCRUBBER				
INPUT,#/HR	0.04	2.68	503.9	0.93
OUTPUT,#/HR	0.03	0.09	427.6	1.03

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 6.20

PHYSICAL PROPERTIES OF
RECYCLED SLURRY

PH	8.15
CONDUCT.MICROMHOS	340.
SPECIFIC GRAVITY	1.038

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM-OUTPUT DATA PAGE 1

RUN NUMBER 17-J   DATE 9-28-71   TIME OF DAY 1600

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	SO3 PPM	NOX PPM	FLYASH GR/DSCF	HUM. #/#	DEW POINT F	DRY FLOW #/HR	STAT PRES IN.H2O
PRIMARY AIR	472.	130.0	------	-----	-----	-------	0.018	78.7	463.	16.3
SECONDARY AIR	4537.	690.0	------	-----	-----	-------	0.021	83.1	4445.	6.1
FURNACE EXIT	5395.	580.0	1951.5	*****	*****	*******	0.062	118.6	5081.	0.0
PART.SCRB.INLET	5395.	475.0	******	*****	*****	*******	0.062	118.6	-----	2.7
PART.CYC.EXIT	3373.	138.0	1692.4	*****	*****	*******	0.143	144.7	2951.	-8.1
VENT ABS.INLET	*****	******	******	*****	*****	*******	******	*****	-----	*****
ABS CYC.EXIT	*****	******	******	*****	*****	*******	******	*****	-----	*****
FLOATING BED IN	3373.	132.0	******	*****	*****	*******	0.143	144.7	-----	-8.1
FLOATING BED EX	3495.	0.0	******	*****	*****	*******	0.171	149.4	-----	-16.3
P.P. EXIT ORIF.	3495.	130.0	18.9	*****	577.	*******	0.171	149.4	2986.	-16.3

SCRUBBER STREAM DATA

PARTICULATE	TEMP,F	FLOW,GPM
MAKEUP WATER	60.0	0.0
PRODUCT LIQ.	137.0	0.0
RECIRCULATED LIQ.	137.0	19.78

GAS ABSORBER	VENTURI ABSORBER TEMP,F	VENTURI ABSORBER FLOW,#/M	FBA TEMP,F	FBA FLOW,#/M
MAKEUP WATER	*****	*****	60.0	0.8
MAKEUP MGO SL.	*****	3.2	0.0	3.2
PRODUCT LIQ.	*****	*****	137.0	0.0
REC.(SPRAY NOZ)	*****	*****	137.0	0.0
REC.(FLOW NOZ.)		*****		385.0

FURNACE PERFORMANCE	
HEAT RELEASE,BTU/HR	0.514E 07
% FUEL AS COAL	96.1
COAL FLOW RATE,#/HR	405.9
NAT.GAS FLOW,#/HR	9.0
% EXCESS AIR	17.1
OXYGEN,%DRY,MEAS.	3.60
CO2,%DRY-CALC.	14.94
HUMIDITY,#/# - CALC.	0.062

SCRUBBER PERFORMANCE	PART.	VENT ABS.	FLOAT.BED
SO2 ABSORB.EFF	13.28	******	98.88
FLYASH COL.EFF	******	******	******
SO3 ABSORB.EFF	******	******	******
NOX ABSORB.EFF	******	******	******
GAS VELOCITY,FPS	92.1	******	5.9
LIQ/GAS,GAL/MCF	21.7	******	61.2
LIQ/GAS,#/#	2.9	******	6.6
PRES.DROP,IN.WG	2.8	******	8.6

SO2 ABSORPTION PARAMETERS

VENTURI ABSORBER		FLOATING BED ABSORBER	
KGA,#MOLE/HR-FT3,	= ******	KGA,#MOLE/HR-FT3	= 27.8
SULFITE/SO2-MOL/MOL	= ******	SULFITE/SO2-MOL/MOL	= 1.31
SUMP RESID.TIME,MIN	= ******	SUMP RESID.TIME,MIN	= ******

SULFATE FORMATION PARAMETERS

CONC.,GM-MOLE/L=	******
MOL% TOTAL SULF=	*****
O2 AT FURN. EX.=	3.60
O2 AT ABSORB.IN=	*****
O2 AT ABSORB.EX=	*****

***** MEANS ITEM NOT MEASURED

MAGNESIUM BASE SLURRY SCRUBBING PROGRAM - OUTPUT DATA PAGE 2

RUN NUMBER 17-J   DATE 9-28-71   TIME OF DAY 1600

MATERIAL BALANCES

	SULFUR	MAGNESIUM	FLYASH	WATER	DRY GAS
FURNACE					
INPUT,#/HR	15.02	------	30.03	295.1	5074.
OUTPUT,#/HR	10.36	------	******	314.4	5081.
PART.SCRUBBER					
INPUT,#/HR	10.36	------	******	377.	5081.
OUTPUT,#/HR	5.22	------	******	422.	2951.
SO2 ABSORBERS					
INPUT,#/HR	5.22	5.38	******	656.	2951.
OUTPUT,#/HR	0.06	******	******	509.	2986.

INPUT FOR EQ. - KIN.PROG.

INPUT FLOWS,#ATOMS/100#FEED

CARBON	0.464699
HYDROGEN	0.629736
OXYGEN	1.394463
NITROGEN	5.058205
SULFUR	0.008817

FEED RATE,#/SEC= 1.48

ENTHALPY,BTU/# = -6372.

*SO2 ABSORBERS- PRODUCT COMP.	GM SO2/ 100ML	GM-MOLE/ LITER	GRAM/ 100ML
TOTAL,	2.86	0.4474	------
COMBINED	2.86	0.4474	------
FREE	0.0	0.0	------
MONO(TOTAL)	2.86	0.4474	------
MONO(DISSOLVED)	0.06	0.0094	0.097
MONO(SOLID)	2.80	0.4380	9.286
BISULFITE	0.0	0.0	0.0
MGO	3.85	0.6020	2.408
SULFATE	*****	******	******
MAGNESIUM	6.72	1.0494	------
FLYASH	-----	------	******
SOLIDS,MG	-----	------	11.264

MAKEUP MGO COMPOSITION

SLURRY CONC.- GM MGO/100ML = 4.60
MGO PRESLAKED, NO=0, YES=1 0
% SLAKED TO MG(OH)2,MEAS. = ******

PRODUCT MG BASE PHYSICAL PROPERTIES

ACID STRENGTH, PH = 8.05
SP.GRAVITY,HYDROM. = *******

PARTICULATE SCRUBBER PRODUCT

ACID STRENGTH , PH = 5.25
FLYASH CONC. GM/100ML = *****

COAL COMPOSITION-MASS

CARBON	0.7150
HYDROGEN	0.0485
OXY+NIT	0.0817
SULFUR	0.0370
ASH	0.0740
WATER	0.0438

*SOLIDS FREE BASIS, MASS/VOLUME SOLUTION

RUN NUMBER 17-J DATE 9-28-71 TIME OF DAY 1600

FLUE GAS DATA	FLOW #/HR	TEMP. F	SO2 PPM	NOX PPM	NOX*1 PPM	NOX*2 PPM	HUM. #/#	DEW POINT F	STAT PRES IN.WG
FURNACE EXIT	5395.	580.0	1951.5	******	******	815.7	0.062	118.6	0.0
FLOAT.BED EX	3495.	130.0	18.9	576.6	******	704.9	0.171	149.4	-16.3
NOX SCRUB IN	3466.	166.0	******	1194.6	609.6	856.0	0.171	149.4	1.4
NOX SCRUB EX	3503.	129.0	******	1223.1	451.1	916.4	0.183	153.2	0.0

NOX SCRUB.DATA	TEMP. F	FLOW #/MIN
MAKEUP WATER	60.0	0.81
MAKEUP MGO	60.0	0.85
PRODUCT LIQ.	130.0	2.15
RECIRC. LIQ.	130.0	1260.

NO2 FLOW DATA

NO2 FLOWRATE,#/MIN	0.04
NO2/NO(PDS BASIS)	1.07
NO2/NO(FC & ROTO)	0.70

SCRUB.PERFORMANCE

SO2 ABSORB.	******
NOX ABSORP.	-2.38
NOX1 ABSORP	25.99
NOX2 ABSORP	-7.06
GAS VEL.FPS	1.7
L/G,GAL/MCF	155.0
L/G,#/#	21.8
PRES.DROP,WG	0.2

SPRAY SLURRY ANALYSIS

MGO,GM/100ML	-0.0
MGSO3(SOLID),M	0.0
MGSO3(TOTAL),M	0.0
MGSO4,MOLAR	0.0056
MG(NO2)2, MOLAR	0.0215
MG(NO3)2, MOLAR	0.0046
TSS,GM/100ML	20.148
NITRITE/NITRATE	4.674

MATERIAL BALANCE

NOX SCRUBBER	SULFUR	MAGNESIUM	WATER	NITROGEN **
INPUT,#/HR	0.06	4.22	597.6	1.62
OUTPUT,#/HR	0.02	0.10	544.6	1.75

MAKEUP MGO COMPOSITION
SLURRY CONC.,GM MGO/100ML= 13.80

PHYSICAL PROPERTIES OF RECYCLED SLURRY

PH	8.50
CONDUCT.MICROMHOS	321.
SPECIFIC GRAVITY	1.042

NOX = PDS ANALYSIS
NOX*1 = SALTSMAN ANALYSIS
NOX*2 = FUEL CELL ANALYSIS

** OXIDIZED NITROGEN ONLY