625/2-77-011

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CAPSULE REPORT

FIRST PROGRESS REPORT:

WELLMAN-LORD SO_2 RECOVERY PROCESS— FLUE GAS DESULFURIZATION PLANT

U.S. EPA
OFFICE OF
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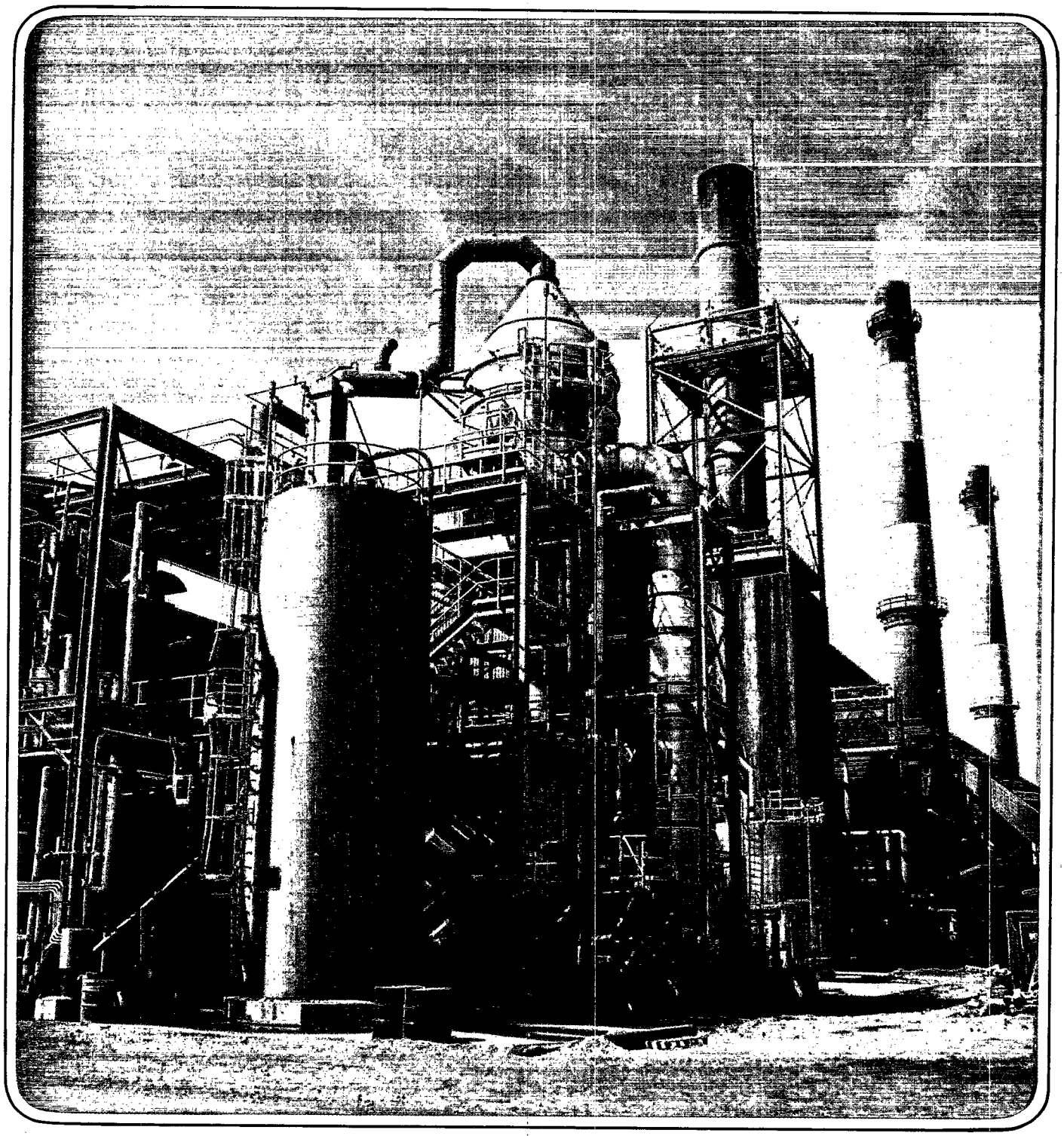

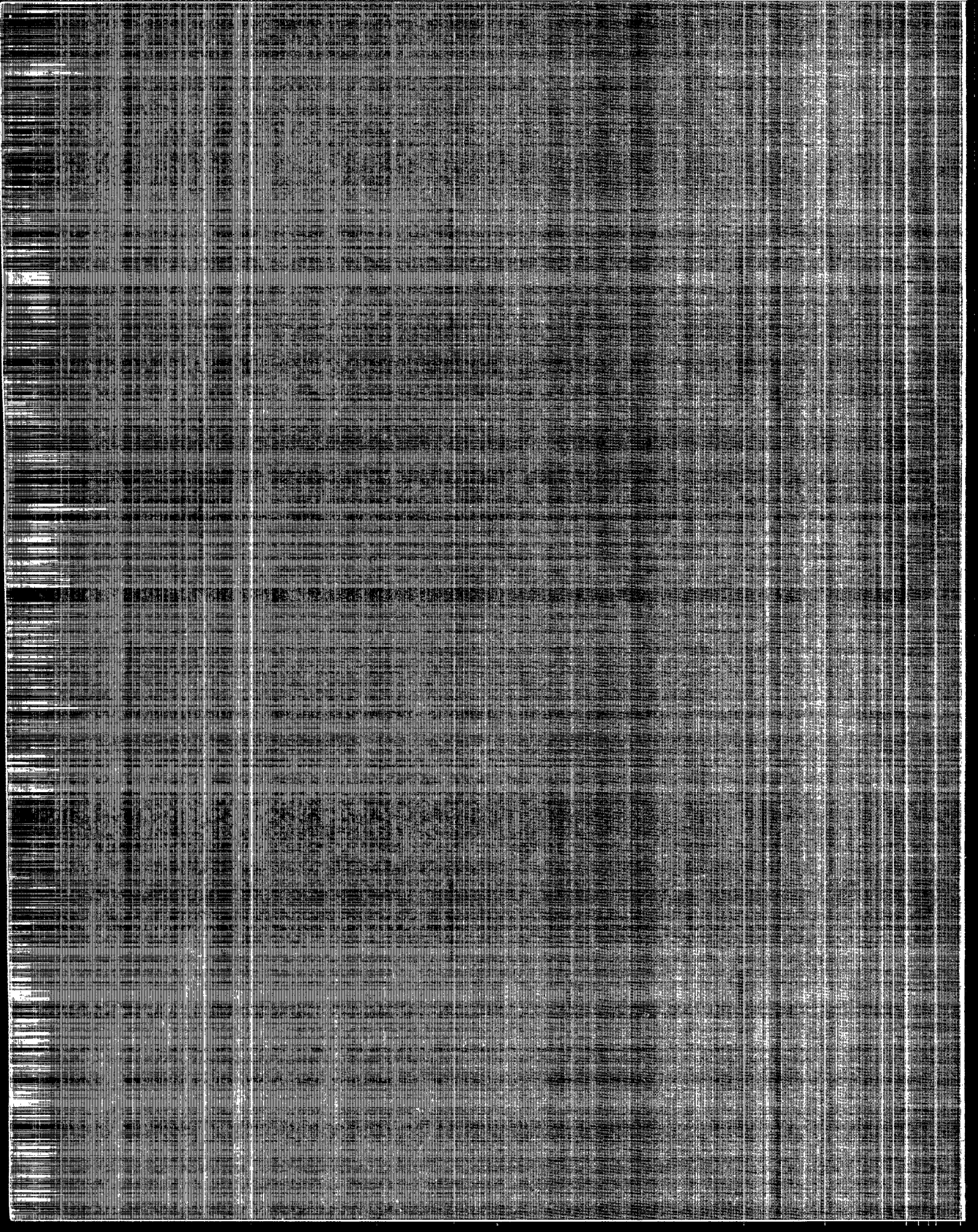

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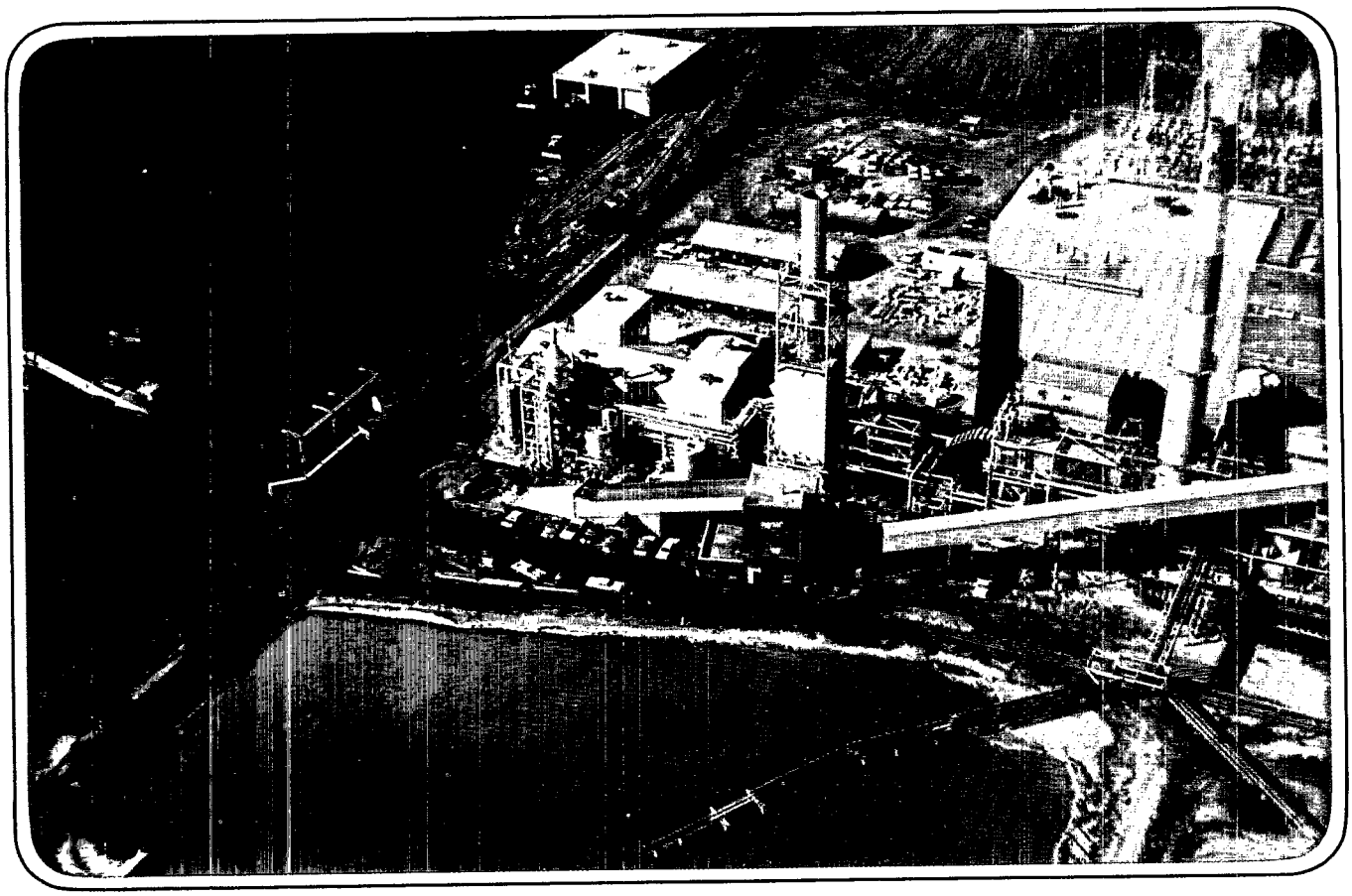


FGD Plant at Dean H. Mitchell Station

1. INTRODUCTION AND SUMMARY

INTRODUCTION

This capsule report describes initial results from a joint program being conducted by Northern Indiana Public Service Company (NIPSCO) and the Environmental Protection Agency (EPA) to demonstrate the sulfur dioxide (SO_2) removal capabilities of the Wellman-Lord/Allied Chemical flue gas desulfurization (FGD) facility. The FGD demonstration plant is retrofitted to the Unit No. 11 coal-fired boiler at NIPSCO's Dean H. Mitchell Station in Gary, Indiana. The FGD plant consists of the Davy Powergas Inc. (Davy) proprietary design Wellman-Lord SO_2 Recovery Process (W-L SO_2 Recovery), Davy's Purge Treatment Unit, together with Allied Chemical Corporation's (Allied Chemical) SO_2 reduction process.

This interim report summarizes the operational progress on the W-L SO_2 Recovery portion of the FGD facility; it is being released at this time because the Acceptance Test has been delayed until summer 1977. The delay is the result of a mishap that occurred on the Unit No. 11 boiler on January 15, 1977. The mishap was completely unrelated to the FGD plant operation.

Because this report predates the period of formal acceptance testing during which the FGD plant must demonstrate that it can meet specific operational criteria for acceptance by the utility, NIPSCO reserves public position statements on the operability, reliability, and efficiency of the plant until such testing has been concluded. This report has been published by EPA with collaboration of Davy Powergas and approval by Allied Chemical and NIPSCO to inform interested people about the preliminary operational experience with the SO_2 recovery portion of an FGD plant.

As would be expected, startup of the FGD facility was done in phases. The first phase, following the initial chemical charge, was the treatment of flue gas in the absorber to remove SO_2. The absorber discharge solutions were stored in the surge tanks. During the second phase, the SO_2-rich solution from the absorber surge tank was heated in the evaporator to reverse the absorption reaction and release a concentrated SO_2 gas stream. When the W-L/Allied Chemical plant is in full operation, this stream will go to the Allied Chemical SO_2 reduction process for conversion to elemental sulfur. To balance the surge tank inventories, the absorber was not operated during the second phase. The third phase was to complete the operational check of the piping system that recycles regenerated absorbent from the evaporator to the absorber. During this period of initial operation, the SO_2 stream was routed to the stack that served Unit No. 11 before the W-L/Allied Chemical facility was built.

SUMMARY

Integrated operation of all units was accomplished during two abbreviated periods; however, the W-L SO_2 Recovery system was operational during the period from July 19 through November 28, 1976. There were three sustained runs on the W-L SO_2 Recovery system. During these runs, it was demonstrated that the system is capable of removing SO_2 from the flue gas at rates greater than 90 percent.

On completion of the repairs to Unit No. 11, in May 1977, the FGD facility will be restarted. After a period of continuous integrated operation, the Acceptance Test will begin. Successful acceptance testing will be followed by a full year of continuous operation and testing.

2. THE FLUE GAS DESULFURIZATION FACILITY

The FGD facility consists of three major process units:

- W-L SO_2 Recovery
- Davy Purge Treatment Unit
- Allied Chemical SO_2 Reduction

The entire FGD plant is operated from a central control room, conveniently located to allow rapid and easy access to all plant facilities.

W-L SO_2 RECOVERY

The W-L SO_2 Recovery system (Figure 1) is a regenerative process and consists of a flue gas booster blower, an orifice contactor (prescrubber), an absorber with three absorption stages, and an evaporator (crystallizer).

Flue Gas Pretreatment

The booster blower delivers the flue gas through the orifice contactor (a variable throat venturi prescrubber) to the absorber. The flue gas is cooled and saturated in the orifice contactor by water/slurry recirculated from the bottom of the prescrubber back to the venturi sprays. The fly ash captured by the scrubbing solution is purged continuously from the system to the pond. Lake water is used for the makeup of water lost via the purge and evaporation.

Absorption

The absorption of the SO_2 from the prescrubbed flue gas takes place in three absorber stages. Each absorber stage consists of a valve tray and a collector tray.

A sodium sulfite solution absorbs and chemically reacts with the sulfur dioxide to form sodium bisulfite. A mist eliminator removes entrained liquid droplets from the gas exiting up the absorber stack. There is a direct-fired, natural gas reheat system in the absorber stack so that the clean gas can be reheated, if necessary, for dispersion of the steam plume.

The reactions that take place in the absorber are simplified as follows:

- Sulfur dioxide and sodium sulfite react to form sodium bisulfite:

$$SO_2 + Na_2SO_3 + H_2O \rightarrow 2NaHSO_3$$

- Some oxidation of the sodium sulfite takes place in the absorber and sodium sulfate is formed:

$$2Na_2SO_3 + O_2 \rightarrow 2Na_2SO_4$$

- Makeup sodium carbonate combines with sodium bisulfite to form additional sodium sulfite:

$$Na_2CO_3 + 2NaHSO_3 \rightarrow 2Na_2SO_3 + CO_2 \uparrow + H_2O$$

Evaporator-Crystallizer

The product solution collected on the bottom collector tray of the absorber overflows to the absorber surge tank. From this tank, the solution is pumped through a filter to insure that no fly ash will enter the evaporator system. A small sidestream of the filtered solution is sent to the purge treatment area to remove the sodium sulfate. The bulk of the product solution is pumped to the evaporator for regeneration of the sodium sulfite.

The evaporation system consists of a forced-circulation vacuum evaporator. The filtered solution is recirculated in the evaporator, where low-

pressure steam is used to evaporate the water from the sodium bisulfite solution. When sufficient water has been removed, sodium sulfite crystals form and precipitate. Sulfur dioxide is removed with the overhead vapors. The slurry formed by the sodium sulfite crystals is withdrawn continuously to the dump/dissolving tank, where condensate from the evaporator is used to dissolve the crystals in the solution that is pumped back to the top stage of the absorber.

The following reaction takes place in the vacuum evaporator:

$$2NaHSO_3 \rightarrow Na_2SO_3 + SO_2 \uparrow + H_2O$$

The water vapor is removed from the sulfur dioxide in water-cooled condensers. The SO_2 is compressed by a liquid ring compressor for introduction to the Allied Chemical SO_2 reduction facility.

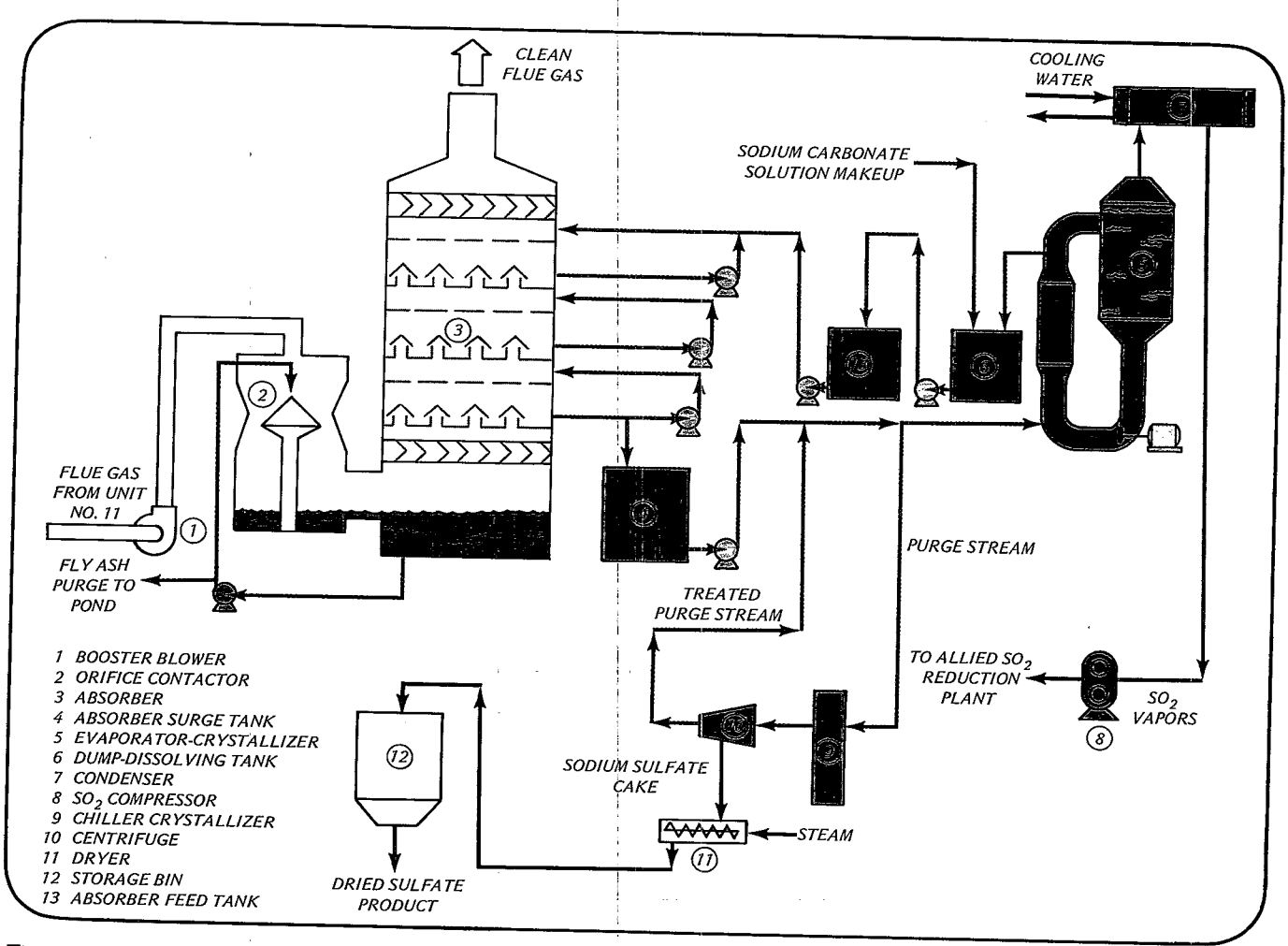


Figure 1. Schematic of W-L SO_2 Recovery System

Makeup

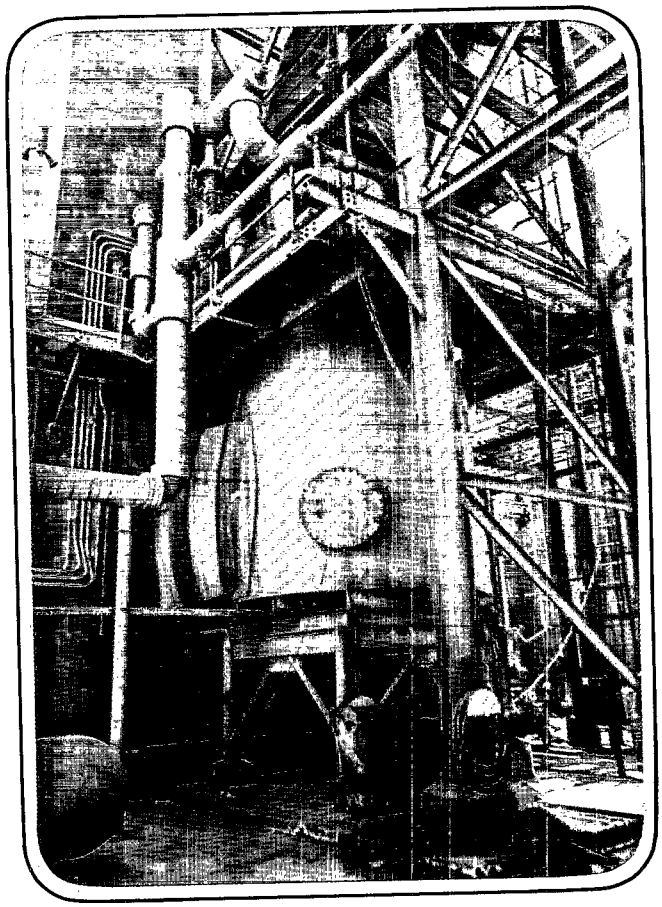
Sodium carbonate (soda ash) is used to replenish sodium lost as sulfate in the Purge Treatment system by the addition of sodium carbonate to the absorber solution. The soda ash is brought to the plant in trucks and is transferred to the storage bin by a pneumatic conveying system. The soda ash is metered to the slurry tanks by a bin activator and belt feeder. The soda ash slurry is pumped to the absorber feed tank by parallel centrifugal pumps.

DAVY PURGE TREATMENT UNIT

The small sidestream of filtered solution from the absorber is pumped to four chilled-wall crystallizers where sodium sulfate crystals form. The crystallized slurry is centrifuged to extract the sodium sulfate crystals. The clear solution is returned to the evaporator feed system. The sodium sulfate crystals are melted and fed to a steam-heated dryer. The dryer discharge product is then stored in a bin until loaded in trucks for shipment. Any gases that evolve from the purge treatment are chemically scrubbed and vented to the atmosphere.

ALLIED CHEMICAL SO_2 REDUCTION PROCESS

The compressed SO_2 is fed to the Allied Chemical SO_2 reduction plant, where it is reacted with natural gas. The resulting elemental sulfur is condensed and stored in molten form for shipment. The off-gases are burned in a tail gas incinerator and returned to the absorber inlet.



Orifice Contactor at Absorber Inlet

3. PERFORMANCE DURING SUSTAINED OPERATIONS

OPERATION PERIODS

The sustained runs of the SO_2 recovery system of the FGD plant cover the periods shown in Table 1.

SO_2 REMOVAL

During the three sustained operating periods, when operating under normal conditions, the absorber demonstrated the capability to remove the SO_2 from the incoming gas at higher rates than those set by the performance criteria. Detailed efficiencies are shown in Figures 2 through 4.

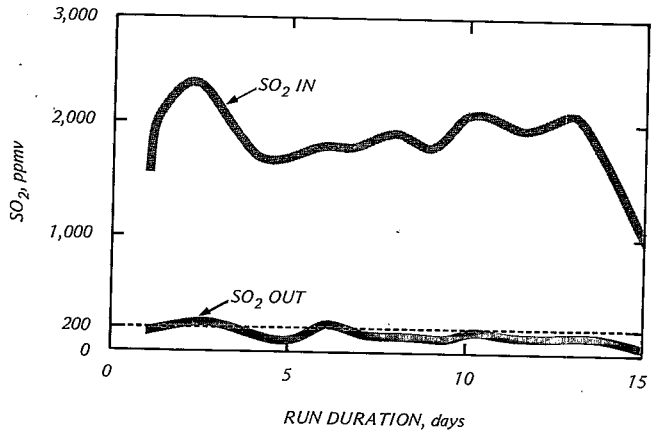
There were some days during the sustained operating periods when only one, two, or three data points were used to calculate the SO_2 removal averages. This lack of data points was most often caused by inoperative instruments.

The criteria for acceptance state that during the Acceptance Test,

> The system when operated with a 3.15 to 3.5 weight % sulfur in the coal shall achieve 90% sulfur removal from

Table 1
PERIODS OF OPERATION OF THE W-L SO_2 RECOVERY SYSTEM

Run No.	Duration (days)	Period
1	15	Sept. 25 through Oct. 9, 1976
2	11	Oct. 13 through Oct. 23, 1976
3	14	Nov. 15 through Nov. 28, 1976



THE SO_2 CONCENTRATION CURVES HAVE BEEN EXTRAPOLATED THROUGH DAYS 3 AND 5 BECAUSE OF INOPERATIVE INSTRUMENTATION.

Figure 2. Inlet and Outlet SO_2 Concentrations During Run No. 1

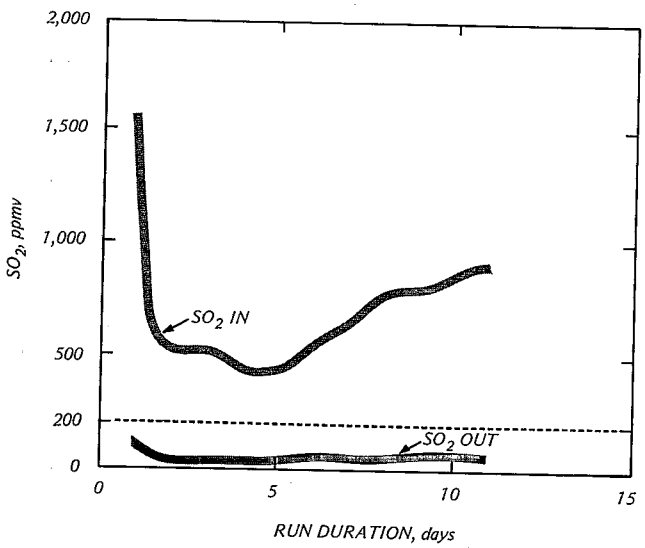
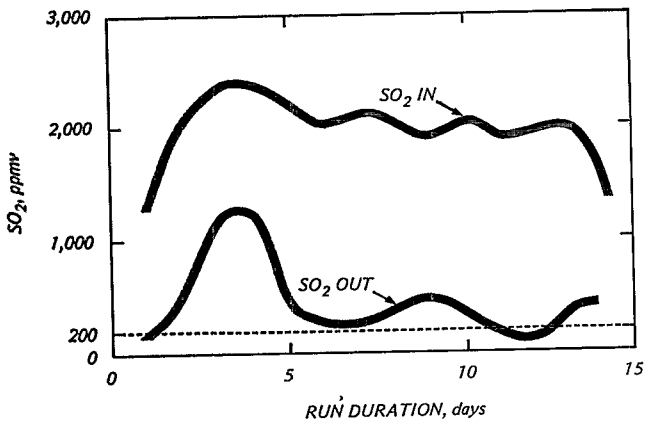


Figure 3. Inlet and Outlet SO_2 Concentrations During Run No. 2



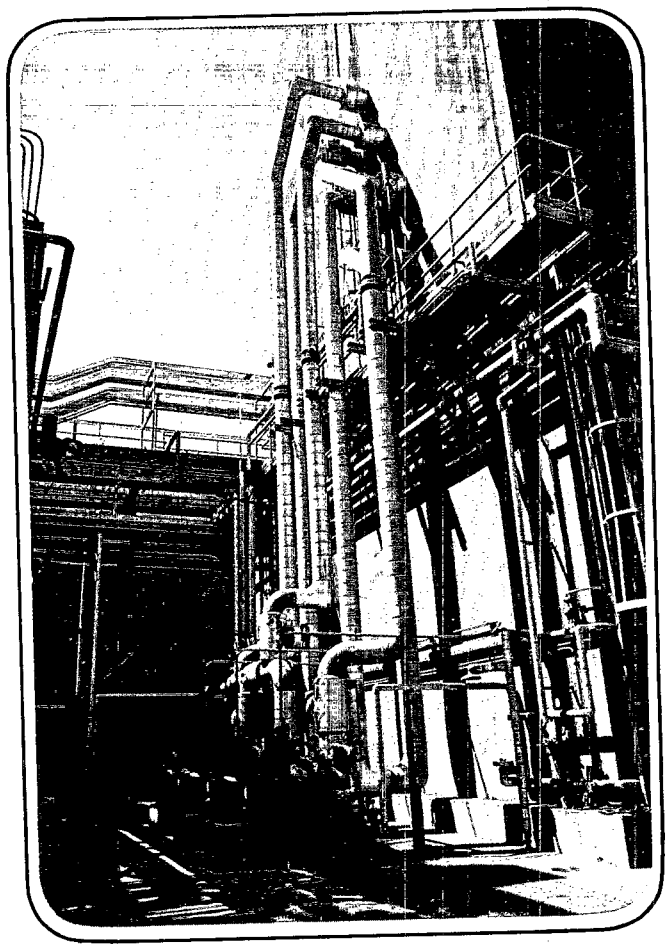
THE POOR SO_2 RECOVERIES DURING THIS PERIOD RESULTED FROM POOR QUALITY SOLUTION CAUSED BY MECHANICAL PROBLEMS IN THE SODA ASH FEED SYSTEM AND EVAPORATION AREA, AND LOW FEED RATES TO THE ABSORBER WHILE BALANCING TANK INVENTORIES.

Figure 4. Inlet and Outlet SO_2 Concentrations During Run No. 3

the flue gas or no more than 200 ppm of SO_2 in the outlet gas stream from the absorber, (which shall be the only source of SO_2 emissions), whichever is the lesser. For fuels containing less than 3.15 weight % sulfur the absorber outlet stream shall contain no more the 200 ppm SO_2. For fuels containing more than 3.5 weight % sulfur the absorber outlet stream shall achieve no less than 90% sulfur removal from the flue gas.

POWER PLANT OPERATION

During the three sustained operation periods, the booster blower delivered flue gas at the fixed rate of 320,000 acfm (the 92-MW design level) to simulate Acceptance Test conditions, while the load on Unit No. 11 fluctuated from 60 MW to 108 MW. The multileaf stack damper was open during the operating periods, which, at times, allowed supplementary flue gas with lower SO_2 concentrations from Unit No. 6 to be pulled across the stack to the absorber.



Absorber Recirculation Piping

4. TEST PROGRAM

When the boiler is operable and a period of integrated operation of the SO_2 recovery and reduction processes has been achieved, the performance of the FGD demonstration plant will be evaluated for EPA by TRW, an independent test and evaluation contractor. The objective of the test program is to obtain the data and provide the information needed to determine the applicability of the process for potential users within the utility industry. The Test Program criteria include these major goals:

- Verify the capability of the W-L SO_2 Recovery Process (1) to meet performance guarantees and (2) to reduce emissions for minimum impact on the environment.
- Verify the capability of the Allied Chemical SO_2 reduction process to produce sulfur of quality set forth in acceptance criteria.
- Determine and report the cost of the demonstration plant in terms of energy and materials consumed.
- Determine and report the technical performance of the demonstration plant, primarily (1) reliability and availability, (2) effect on boiler performance, and (3) flexibility.

The Test Program includes three major tasks:

- The Baseline Test
- The Acceptance Test
- The Demonstration Test and Evaluation

The Baseline Test was conducted in the spring of 1974 and the spring of 1975, and the results were reported in February 1977. During the Baseline Test, extensive sampling of the flue gas was made before retrofit of the FGD plant to chemically and physically characterize the boiler flue gas. Boiler operating performance was also evaluated; included was the establishment of heat rates, efficiencies, air inleakage rates, and electrostatic precipitator (ESP) performance. These data establish a baseline performance to be compared with boiler performance after retrofit of the FGD plant.

An Acceptance Test will be conducted to verify that the process performance guarantees have been met. Over a period totaling at least 15 days, the FGD plant must meet the minimum SO_2 removal requirements of the performance guarantees at two specified levels of boiler load, and must not exceed the specified amounts of raw materials and utilities consumption.

The Demonstration Test and Evaluation will comprise a 1-year continuous test program during which flue gas parameters, boiler operating parameters, and selected performance parameters for the FGD plant will be recorded by a system that permits continuous monitoring of 45 parameters and includes a data acquisition system for scanning the sensor outputs at 2.5- or 5.0-minute intervals. The data are stored on magnetic tape. Where continuous monitoring is not possible, data are collected at lesser frequencies or intermittently. Three intensive test periods totaling approximately 9 weeks have been set aside during the demonstration year to conduct additional tests, which include:

- Tests for collection of data not amenable to continuous monitoring
- Tests at specified normal operating conditions of the boiler
- Tests at specific operating conditions not normal for the boiler
- Tests using manual sampling and analytical techniques for the measurement of flue gas parameters

In response to the major objectives of the Test Program, the data will be evaluated with major emphasis on determining the pollutant reduction performance of the FGD plant. Data results and interpretations will be incorporated in a comprehensive test report at the completion of the Test Program, currently scheduled for August 1978. The results will also be summarized in interim reports submitted periodically during the demonstration.

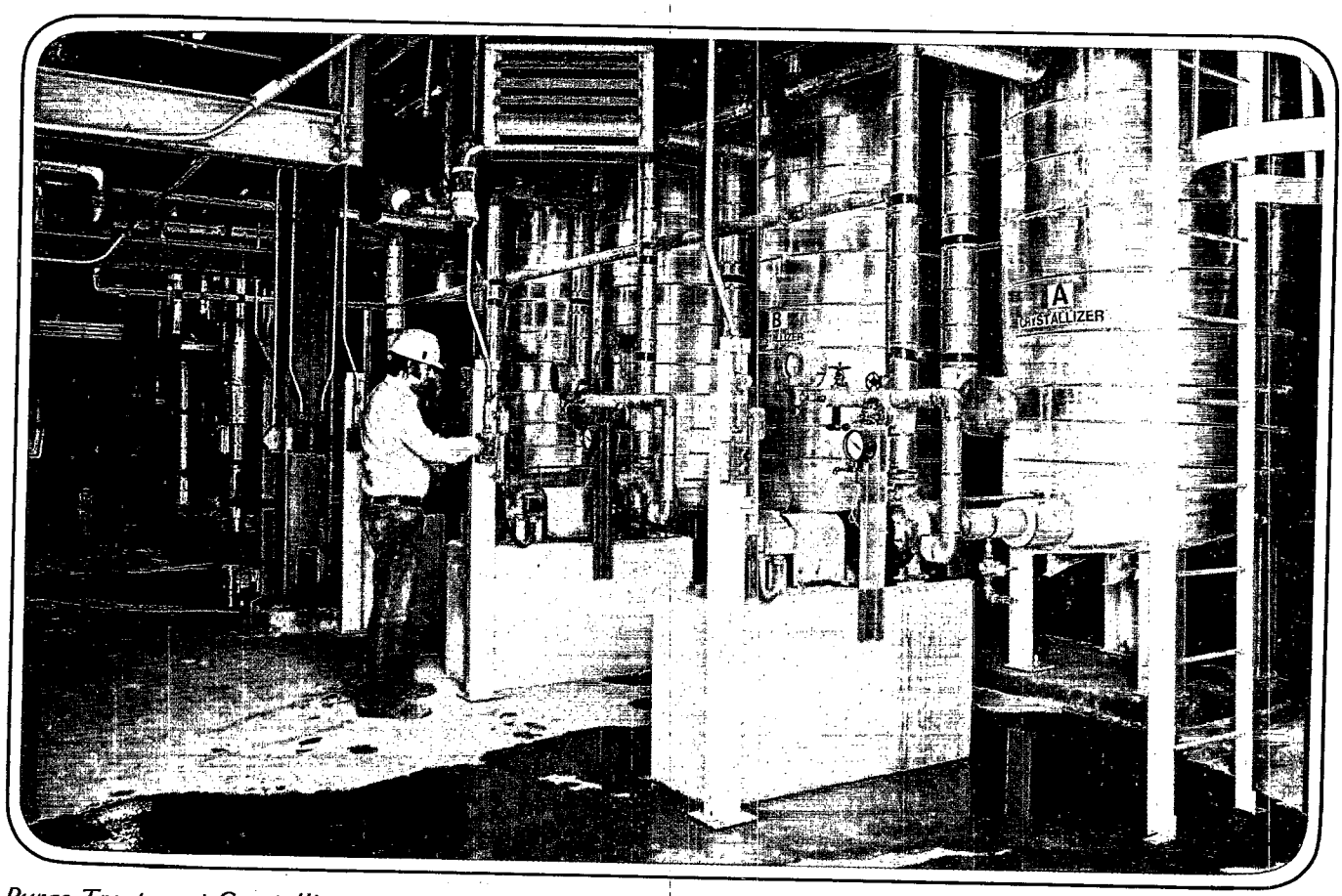
6. PROBLEMS ENCOUNTERED

During the operation of the FGD plant between July 19 and November 28, there were some major problems encountered both by the power plant and the FGD plant. These problems all played major roles in the delay of plant startup, integrated operation, and the Acceptance Test. All these known problems have been solved at this time, and there should be no cause for further delays.

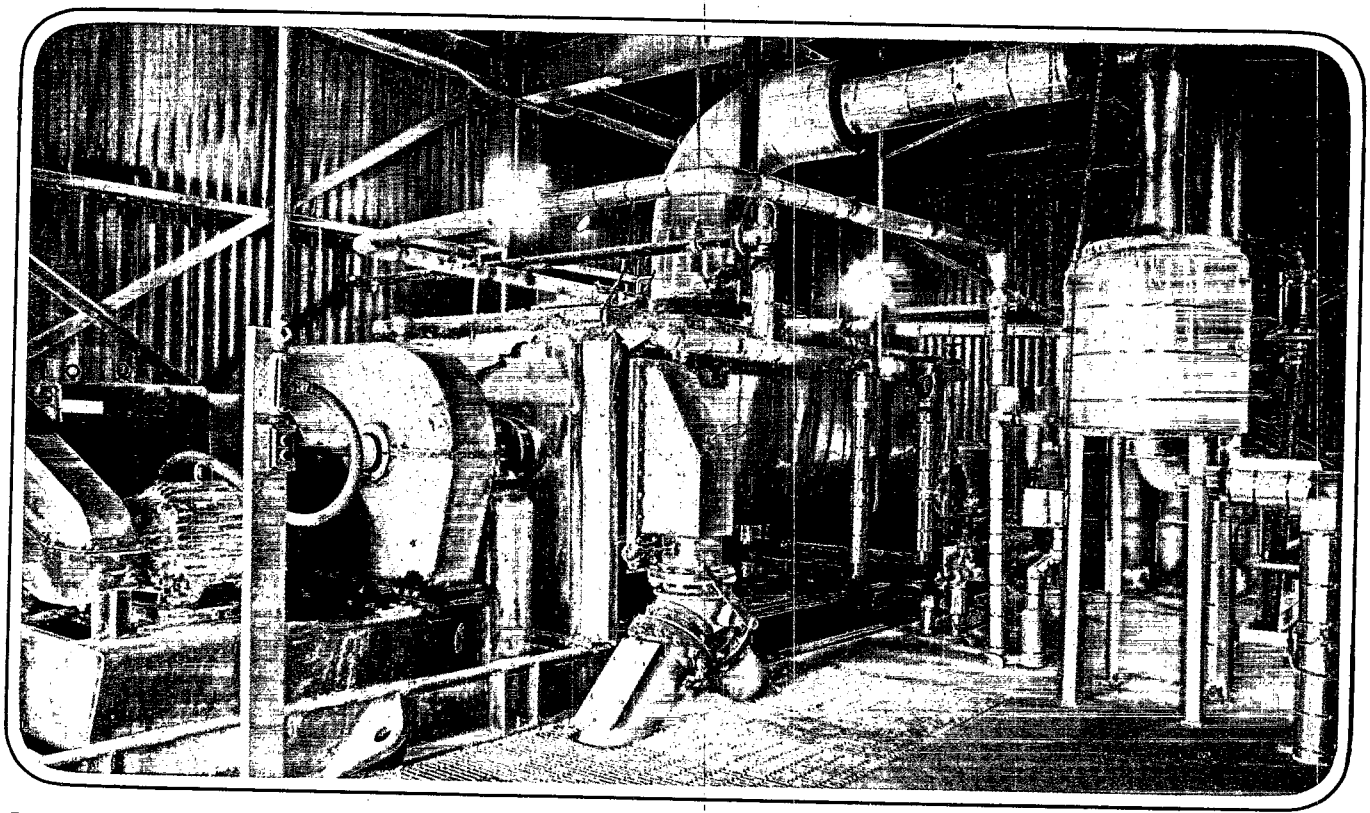
The major problems encountered in the FGD plant, along with the corrective action, are listed in Table 2.

Table 2
PROBLEM HISTORY OF FGD PLANT

PROBLEM	SOLUTION
No absorber turndown. The absorber was to operate between 46 MW and 110 MW without dumping the liquid from valve trays.	The valve trays were leveled to within 1/8 inch across a distance of 25 feet. Some valve cap weights were changed and some valves were replaced with a different valve type.
The collector tray seals leaked at the walls.	The original seal material between the metal tray and the tile wall of the absorber failed. This material was removed and replaced with packing and silicone caulking.
Absorber roof and stack joint leaks occurred.	The gaskets between the top of the absorber wall and cover and between the reheat venturi and the stack were reinforced.
Temperature control of the low-pressure steam was inadequate.	The desuperheater on the low pressure steam line was relocated to give better steam saturation and temperature controls.
There was corrosion on bottom surface of the lower collector tray.	The bottom surface of the collector tray (exposed to flue gas) was sand-blasted and lined with cured rubber.
SO_2 analyzer sample probes became plugged.	Newly designed, traced, and air purged sample probes have been installed, eliminating the plugging.
Piping changes were made to the stack reheat system.	The size of the ring header supplying natural gas to the four burners was increased, and new regulators were installed to maintain steady gas pressure to all four burners.
Low pressure occurred in emergency steam supply piping to the FGD plant.	NIPSCO removed the flow meter orifice in the emergency steam line.



Purge Treatment Crystallizers



Purge Dryer

7. TEST RUN SCHEDULE

NIPSCO is currently making repairs to the damaged Unit No. 11 boiler. The unit is scheduled to be back on line in May with the main steam supply available to the FGD plant shortly thereafter. Total integrated operation is planned for mid-June, with the Acceptance Test to begin in July. Figure 5 shows the schedule for the other related plant activities.

During the Acceptance Test, the FGD plant will be tested at the 92-MW level for 12 days, and at the 110-MW level for 83 hours.

During the demonstration year the FGD plant will be operated at varying levels and on a wide variety of coals. It will also be tested at varying particulate matter loadings in the flue gas.

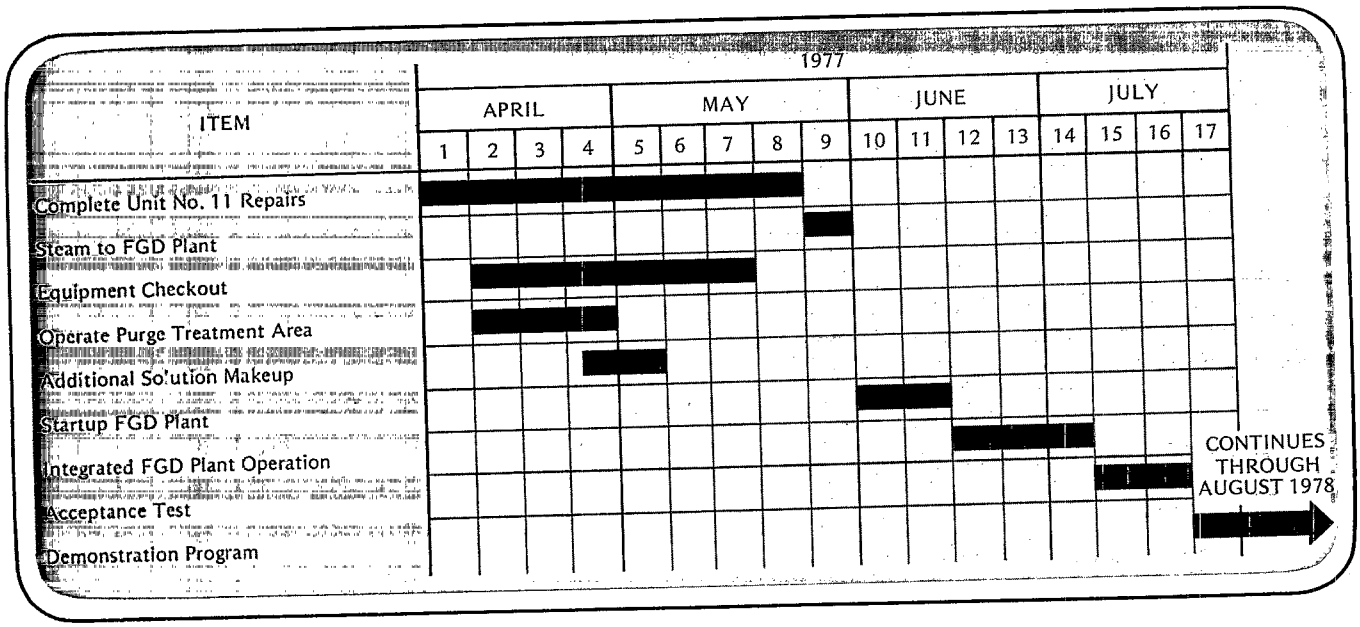


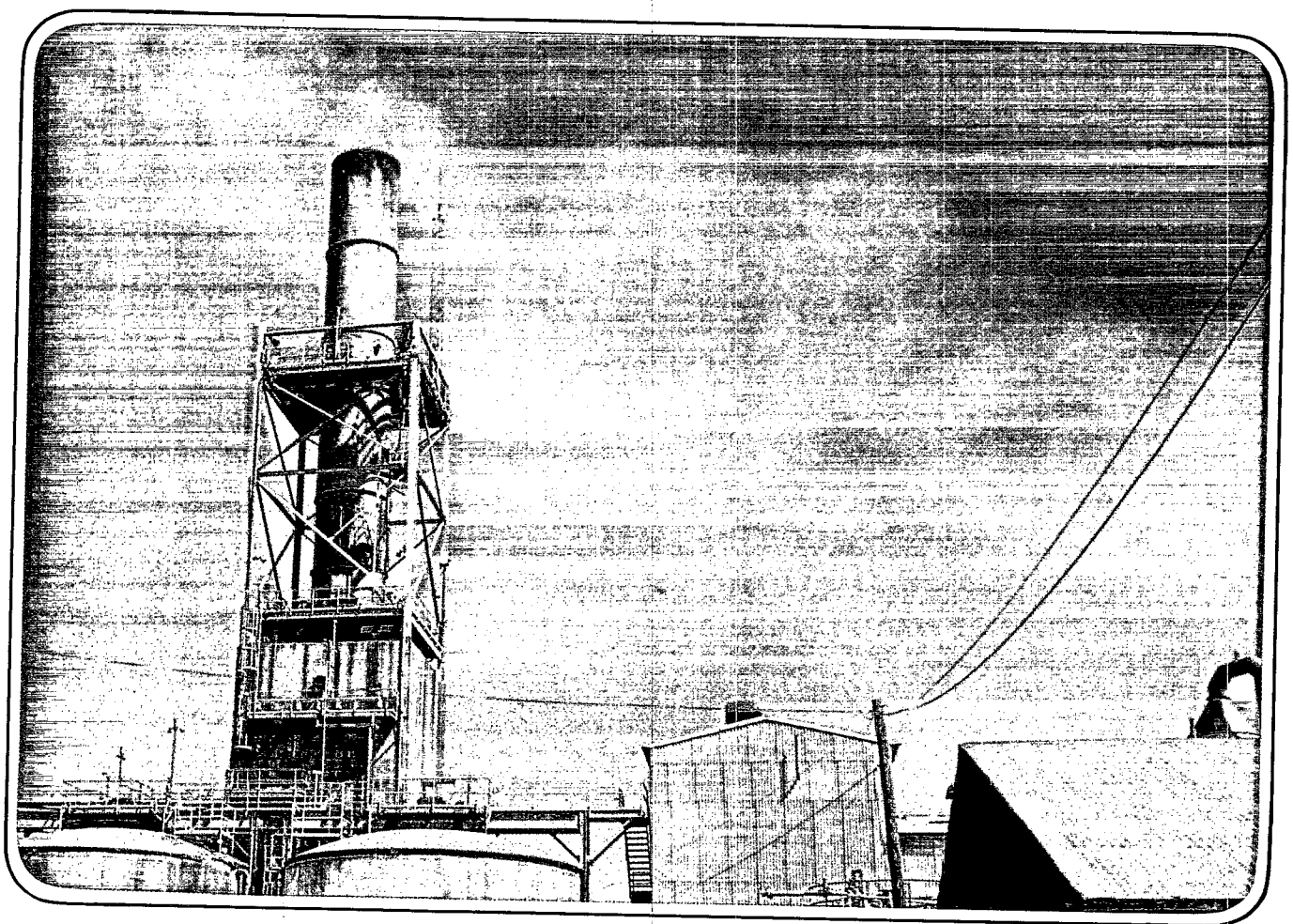
Figure 5. Davy FGD Plant Operation Schedule in Weeks

8. REPORTS

Following successful completion of the Acceptance Test, EPA will issue another progress report, with a final report to follow the 1-year demonstration period. The Baseline Test report was issued in February 1977, and two films reporting progress at the FGD plant will be released in future months.

This report has been jointly prepared by the Environmental Research Information Center (Technology Transfer) and the Industrial Environmental Research Laboratory (Research Triangle Park). Another capsule report is planned to summarize and discuss the final test results. For further information on the NIPSCO and other EPA-sponsored FGD programs, write:

Utilities and Industrial Power Division
Industrial Environmental Research Laboratory
Environmental Protection Agency
Research Triangle Park, N.C. 27711



FGD Absorber and Stack With Surge Tanks in Foreground

★ US GPO: 1977—758—801