**ORIMULSION TEST BURN**

**SANFORD PLANT, UNIT NO. 4**

**JANUARY - MAY, 1991**

# PILOT-SCALE EMISSIONS CONTROL EQUIPMENT

## FINAL REPORT

**November 18, 1991**

1270009[illegible]-AC
PSD-FL-150
Pats # 64180842

**FLORIDA POWER & LIGHT CO.**

**BY: K. R. Olen, Ph.D**

FPL

P. O. Box 078768, West Palm Beach, FL 33407-0768

FEDERAL EXPRESS

November 18, 1991

C. H. Fancy, Chief
Bureau of Air Regulation
State of Florida
Department of Environmental Regulation
2600 Blair Stone Road
Tallahassee, Florida 32301

RECEIVED
NOV 19 1991
Division of Air
Resources Management

RE: **Sanford Plant, Unit No. 4**
**Orimulsion Test Burn**

Dear Mr. Fancy:

As discussed in my letter to you of November 5, 1991, and in compliance with Specific Condition No. 8.g) of the permit authorizing the Orimulsion Test Burn at our Sanford Plant, Unit No. 4, enclosed please find a copy of the final report prepared by FPL on the results of the pilot pollution control equipment test conducted during the Test Burn. As also required in Specific Condition No. 8.g), the report includes an ultimate analysis of the Orimulsion fuel.

We appreciate your continued cooperation. Please call me at (407) 697-6926 if you have any questions.

Sincerely,

Elsa A. Bishop

Elsa A. Bishop
Senior Environmental Specialist
Florida Power & Light Company

EAB:jm

Enclosure

cc: A. Alexander - DER/Orlando (w/o attach.)
C. Collins - DER/Orlando (w/attach.)
C. Phillips - DER/Tall (w/o attach.)

FPL

P.O. Box 078768, West Palm Beach, FL 33407-0768
5500 Village Blvd.

FAXED

May 13, 1991

1270009-NA-AC
PSD-FL-150
Pats #64180842

Mr. A. Alexander, Deputy Assistant Secretary
State of Florida Department of Environmental Regulation
Central Florida District
3319 Maguire Blvd., Suite 232
Orlando, Florida 32802

RE: **Sanford Plant, Unit No. 4**
**Orimulsion Test Burn**
**Emissions Testing -**
**Vanadium Pentoxide**

Dear Mr. Alexander:

Please be advised that, on Friday evening, May 10, 1991, Sanford Plant was notified that, due to operating problems with two of our major units which caused those units to come off-line, Sanford Unit No. 4 would be taken off Orimulsion and fired on oil in order to be able to operate at full load, with Sanford Unit No. 5 also on oil. At the time, Entropy Environmentalists were on site conducting some parametric testing, and were scheduled to return on Monday, May 13th, for two additional days of parametric testing and one day of emissions testing for Vanadium Pentoxide, as previously notified.

In light of the need to have Entropy complete the testing underway, Sanford Unit No. 4 was allowed to remain on Orimulsion over the weekend and the Entropy schedule was accelerated. Thus, the Vanadium Pentoxide test scheduled for Tuesday, May 14th, was actually conducted on Sunday, May 12th.

Following the Sunday test, Sanford Unit no. 4 was taken off Orimulsion and is not expected at this time to resume Orimulsion firing until Thursday, May 16th, when it is expected that the FPL System will regain generating stability. At such time as Orimulsion firing is resumed, associated conditions will also resume.

Please call me at (407) 697-6926 if you have any questions.

Sincerely,

Elsa A. Bishop

Elsa A. Bishop
Senior Environmental Coordinator
Florida Power & Light Company

EAB:jm
Enclosure

cc: Charles M. Collins - DER/Orlando
Cindy Phillips - DER/Tall

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# 1.0 PILOT-SCALE EMISSIONS CONTROL EQUIPMENT

## 1.1 Background

In comparison to residual fuel oil the higher ash and sulphur content of Orimulsion necessitates particulate control and flue gas desulphurization systems be installed for full-scale conversions. The fineness of Orimulsion fly ash and its chemical characteristics provide special concerns for the selection and design of effective, efficient and environmentally acceptable control systems. A preliminary review of particulate control options, for example, suggested that the submicron-sized fly ash might produce unacceptable re-entrainment problems in the operation of an electrostatic precipitator (ESP), and prohibitively high pressure drops in a fabric filter, or baghouse.

The only reported experience in attempting to collect and contain Orimulsion fly ash was from a Venezuelan-sponsored demonstration in a 100MW corner-fired boiler at the Dalhousie Generating Station of New Brunswick Electric Power Commission in Canada (1). Although the ESP used in the NB Power demonstration achieved about 90% collection efficiency, undesirable opacity excursions were experienced when the collection plates were rapped to remove the collected particulate. Minor opacity spikes during ESP rapping are considered normal, however, at Dalhousie the opacity spikes were close to 40%. The resistivity of Orimulsion fly ash is between 3 and $5 \times 10^{11}$ ohm-cm, suggesting that high opacity excursion should not occur in a properly designed and operated ESP. The designed specific collecting area (SCA) of the NB Power ESP was 324 $ft^2$/1000 acfm. Unfortunately the ESP operated at a much lower effective SCA, because the flue gas temperature was higher than that permitted by the design. The higher flue gas temperatures produced higher gas velocities, which prevented any significant particulate collection in the first or second fields. As a result all of the fly ash was being collected in the third field. This situation afforded no protection to contain the fine fly ash during rapping. NB Power personnel concluded that Orimulsion fly ash could be collected and contained with an ESP, however the final size of a suitable ESP had not been established when the Sanford Test Burn Plan was being developed.

Since the space required for environmental control systems would be a major concern in the conversion of FPL fossil plants to Orimulsion, attention was directed to the possibility of using fabric filters, or baghouses, for Orimulsion particulate control. EPRI advised that the fabric filters with air to cloth ratios of 4:1, or higher, might be more cost effective and require less space than ESP's with SCA's greater than about 300 $ft^2$/1000 acfm (2). In addition, fabric screening tests were recently completed on fly ash from a residual oil fired boiler at Consolidated Edison Company's Arthur Kill Station (3). These tests strongly suggested that Orimulsion fly ash could be collected and contained with a fabric filter without incurring 'blinding' of the bag fabric with the submicron particles. As a result, two different types of pilot-scale fabric filter systems were included for evaluation as part of the Orimulsion Test Burn. These systems are described in Section 1.2.

Based on the experience at coal-fired utility boilers, the selection of a flue gas desulphurization (FGD) process can readily be made. Two general classes of FGD processes dominate the industry, i.e., wet limestone forced oxidation and lime spray drying. The wet limestone forced oxidation process requires considerable capital investment, and produces gypsum as a byproduct. In comparison, the lime spray drying process is less capital intensive, but is more expensive to operate, due to the higher cost of lime compared to that of limestone. In addition, the FGD product from lime spray dryers must be stabilized and landfilled as it appears to have no commercial value. Spray dryer systems have been used to desulphurize the flue gas from low and medium sulphur fuels and municipal solid waste, while the wet limestone processes have been used for both medium and high sulphur fuels. Recent tests at EPRI's High Sulphur Test Center and in Europe demonstrated that spray dryer technology could be successfully applied to high-sulphur fuels, such as Orimulsion, but with high operating cost.

There was no apparent justification to include an evaluation of a conventional wet limestone scrubber or lime spray dryer in the Orimulsion Test Burn. With accurate flue gas volume, composition and temperature data, these systems can be designed to desulphurize Orimulsion flue gas.

Since either of the conventional FGD processes may require considerable amounts of process water and space for solid waste disposal, a review of emerging byproduct processes was conducted. The byproduct processes produce concentrated sulphur dioxide gas or sulphuric acid, while regenerating the FGD sorbent solution. Either of these commodity chemicals has high marketability in Florida. In a 1986 EPRI study (4) several emerging new byproduct processes, as having potentially lower capital and operating costs than existing byproduct processes, were identified. Of those processes identified in the EPRI study only the Aquatech SOXAL Process had not been adequately demonstrated, or was in the process of being demonstrated, when the Sanford Test Burn Plan was being developed. An evaluation of the SOXAL Process was included in the Orimulsion Test Burn, after completing a detailed review with EPRI and Aquatech personnel. A detail description of the SOXAL pilot plant and the associated alkali scrubber is provided in Section 1.3.

Following the experience at Dalhousie, it was concluded that Orimulsion fly ash collected upstream of a FGD system could be marketed as a vanadium ore. Accordingly a materials handling system was installed to collect the fly ash from one of the pilot-scale fabric filters. It was believed that the experience gained from operating this system would provide important data for future design of waste handling systems. The FGD system is described in Section 1.2.4.

A schematic drawing showing the arrangement of the air emissions control pilot testing configuration at the Sanford Plant is presented in Figure 4.1.

## 1.2 PILOT-SCALE FABRIC FILTER SYSTEMS

Two different types of pilot-scale fabric filters were installed for evaluation during the Orimulsion Test Burn: A nominal 5000 acfm Howden pulse-jet fabric filter and a nominal 14,400 acfm Ecoliaire reverse-gas fabric filter. Arrangements to have the units available for the Test Burn were made by EPRI. In addition, EPRI contracted Southern Research Institute to collect performance data on both fabric filter systems, and Elkem Technologies, Inc. to configure the reverse-gas unit. To provide dust laden gas to the fabric filters slipstreams were installed to divert flue gas from the air preheater outlet duct on either side of the boiler. The South slipstream provided gas to the pulse-jet, while the reverse-gas unit was supplied by the North slipstream. Special collection tubes, see Appendix 3.1, were fabricated and installed to insure that the gas in the slipstreams were representative of the boiler flue gas. Induced draft fans located on the clean side of the filters were used to draw flue gas into the units. The outlet gas from the pulse-jet fabric filter was ducted directly into the inlet side of the boiler ID fan. The outlet from the reverse-gas fabric filter also was ducted to the inlet of the boiler ID fan, but had a bypass connection to the pilot-scale flue gas desulphurization system, see Section 1.3.

### 1.2.1 Reverse-Gas Fabric Filter

The reverse-gas unit is representative of the traditional multi-compartment baghouse, wherein the particulates are collected on the inner surface of cylindrical tube-shaped bags, see Figure 4.2. The bags are clamped to a lower tube sheet and supported at the top with a spring arrangement. Each compartment was sequenced such that cleaning cycles were executed at a fixed time interval regardless of the pressure drop across the tube sheet. During cleaning a compartment was isolated and the process was reversed, or cleaned flue gas was forced back through the bags in the isolated compartment. For more details regarding the operation of the Ecoliaire fabric filter see Appendix 3.2. The pilot-scale test unit like most reverse-gas fabric filters was originally designed to operate with an air-to-cloth ratio of 2:1. Even with long bags this ratio usually results in a very large baghouse that occupies a large area. As space was an important criteria in the selection of the environmental control system, Elkem Technologies was retained through EPRI to configure the reverse-gas unit to operate with a air-to-cloth ratio of about 4:1. Elkem has had commercial success in collecting submicrom sized particulates, particularly in the Norwegian ferroalloys industry, in reverse-gas fabric filters operating with air-to-cloth ratios of 4:1. Each of the four baghouse compartments was designed to accommodate 36 - 8 inch diameter by 288 inch long bags. To achieve a desired gross filtering air-to-cloth ratio of 3.8:1 with a maximum flue gas flow rate of 14,000 acfm, 20 bags were installed in each of the four compartments. All of the installed bags were woven fiber glass with a Goretex membrane on the inner surface. This type of bag does not rely on the formation of a dustcake to achieve high filtering efficiency. See Figure 4.3 for additional description.

### 1.2.2 Pulse-Jet Fabric Filter

The 48-bag, 5000 acfm, Howden pulse-jet fabric filter incorporated a low pressure/high volume system to pulse clean gas down the inside of the bags through a rotating manifold, see Figure 4.4. In contrast to the reverse-gas fabric filer, particulates are collected on the outer surface of felted bags in the pulse-jet fabric filter, while in operation. In addition, pulse-jet fabric filters typically operate at air-to-cloth ratios of 4:1, and as a result are generally much smaller than the reverse-gas fabric filters. For more details regarding the operation of the Howden pulse-jet fabric filter, see Appendix 3.6.

The 240 inch oval-shaped bags, having a nominal surface area of 25 $ft^2$, were mounted in three concentric circles, see Figure 4.5, using a snap-band cuff. Each bag was then suspended from a top tube sheet and mounted over a two-piece, coated, 14-wire cage, which prevented the bag from collapsing during operation.

Several needlefelt bag materials were evaluated during the test program. Forty-two of the forty-eight bags in the pulse-jet fabric filter were made from Huyglas 1701 fabric. DuPont Filter Guard, a Teflon mesh sock designed to prevent fretting wear between the bag and the coated wire cage, was installed under nine of the forty-two Huyglas bags. Three different materials were used on the remaining six bags. Two were Ryton needled onto a Rastex scrim. Two were made from Tefaire, and the last two were made from P84 fabric. The arrangement of the test bags within the pulse-jet fabric filter is shown in Figure 4.6. Table 5.1 reflects the baseline data from four unused needlefelt samples.

### 1.2.3 Precoat Injection System

A precoating system consisting of a hopper, rotary valve, blower and timer, was installed on the gas inlet side of both pilot-scale fabric filters, see Figure 4.7. The system was used to precoat the bags with magnesium oxide prior to filtering Orimulsion fly ash, and during operation when the outlet temperature was reduced to within about 30 degrees of the flue gas acid dew point. The injection rate was approximately 1.4 pounds per minute.

### 1.2.4 Fly Ash Handling System

Fly ash collected in the hoppers under each of the four compartments of the reverse-gas fabric filter was transferred to a central storage hopper by means of rotary valves and a negative pressure transport system. Heated ambient air was pulled through the transport system by a Max-Vac, which was operated on a continuous basis whenever the fabric filter was in service. Given the low bulk density of the collected Orimulsion fly ash, i.e., 5 to 10 lbs/ft$^3$, a negative transport system might be preferred to prevent a fugitive dust problem in the event of a system failure. However, the more traditional lock hopper/positive pressure transport system to handle Orimulsion fly ash collected in the ESP at Dalhousie apparently operated without problems. On an intermittent basis the fly ash collected in the storage hopper was emptied into a Mixer System's DustMaster, see Figure 4.8. The purpose of the DustMaster was to aggolerate the fly ash by adding about 10% water and increase its bulk density for shipping to an ore processor. The same aggoleration system was evaluated during the Dalhousie Demonstration.

The fly ash collected in the hopper of the pulse-jet fabric filter was blown into the outlet duct and back to the main flue gas ducting.

## 1.3 PILOT-SCALE FLUE GAS DESULPHURIZATION SYSTEMS

To support the pilot-scale flue gas desulphurization systems, the outlet from the reverse-gas fabric filter was ducted not only to the inlet of the boiler ID fan, but to the pilot-scale alkali scrubber.

### 1.3.1 Alkali Scrubber

The pilot scale alkali scrubber was built by AirPol, Inc. and consisted of a stainless steel vertical two-stage packed tower with a rated capacity of 10,800 acfm. Flue gas was scrubbed of sulphur dioxide, $SO_2$, in a counter current mode, wherein clean (particulate free) flue gas was introduced into the bottom of the tower, while an aqueous sodium sulfite scrubbing solution was sprayed into the tower near the top. Gas flow to the scrubber was controlled by means of a butterfly-type bypass damper, which was equipped with a pneumatic actuator. Two flow elements, one measuring total slipstream gas flow and the second measuring flow to the scrubber were used to control gas flow. A proportional controller was used to compare the two flows and adjust the bypass damper. A photograph of the alkali scrubber is presented in Figure 4.9. A more detailed description of the alkali scrubber is provided in Appendix 3.3.

### 1.3.2 SOXAL Process

The SOXAL Process is not a FGD process, but an electrochemical process designed to regenerate a sodium sulfite based scrubbing solution used in the alkali scrubber. Critical to the process are bipolar membranes that convert salt solutions to constituent acids and bases. Reacting alkaline sodium sulfite ($Na_2SO_3$ + NaOH) with $SO_2$ produces sodium bisulfite ($NaHSO_3$), and in the presence of oxygen a small amount of sodium sulphate ($Na_2SO_4$). A single membrane SOXAL Process, used during the test burn, separates the bisulfite into $Na_2SO_3$ and sulphurous acid ($H_2SO_3$). Sulphur dioxide can then be concentrated and liquified for sale as a commodity chemical by using a steam stripper to dissociate the suphurous acid. Any $Na_2SO_4$ in the system will be concentrated in the water liberated by the steam stripper. Although a steam stripper was included in the pilot-scale SOXAL Process at Sanford, no attempt was made to isolate the concentrated $SO_2$, instead it was vented back into the outlet duct.

A potential advantage of the SOXAL Process is that it could be located remote from the power boiler, and be operated independent of boiler load. Like other electrochemical processes, the SOXAL Process should be operated at full load on a continuous basis for the best efficiency and lowest maintenance costs. Aquatech envisioned the largest SOXAL unit to be a 10MW equivalent cell. According to expected boiler capacity factor and the required amount of FGD, thirty or more of these cell would be installed to regenerate the scrubbing solution for a 400MW boiler. Large, or multiple, tanks to store both spent sorbent and regenerated sorbent would be installed to insure that the SOXAL cells would operate continuously at full load, and that there was sufficient regenerated sorbent to operate the boiler at any load. The Soxal pilot plant was equipped with sufficient liquid storage capacity both before and after the bipolar membranes to insure that the process could be operated for at least 72 hours without the scrubber in service. Photographs of the two skids that contained the various subsystems that made up the approximately 2MW pilot-scale SOXAL Process are presented in Figure 4.10.

## 1.4 PILOT-SCALE EMISSIONS CONTROL EQUIPMENT TEST RESULTS

The performance data collected by SRI on the reverse-gas and pulse-jet fabric filters, are presented in summary form in Sections 1.4.1 and 1.4.2. More detail information can be found in Appendix 3.5, which are SRI Progress Reports to EPRI. The operation of the bag precoat injection system, and the fly ash transport and agglomeration systems are discussed in Sections 1.4.3 and 1.4.4, respectively. Sections 1.4.5 and 1.4.6 address the performance of the alkali scrubber and the SOXAL pilot process.

### 1.4.1 Reverse-Gas Fabric Filter Performance

The reverse-gas fabric filter was put into service on March 6, 1991. Prior to filtering flue gas, the bags were coated with sufficient magnesium oxide powder to raise the pressure drop by 1.0 in. $H_2O$. Because of unexpectedly high negative static pressure in the existing breaching, the pilot baghouse was itself subjected to very high negative pressures (-25 in. $H_2O$ at the baghouse outlet). Infiltration of ambient air was so great (100°F differential between the baghouse inlet and outlet) that it was impossible to accurately measure the gas flow through the unit.

During an outage in late March and early April, the ducting to the baghouse was revised such that the induced draft fan was converted to a forced draft fan, and the baghouse then operated at essentially atmospheric pressure. Following these changes, the pilot baghouse was restarted on April 3, 1991. Accurate measurement of flow was now possible and the temperature loss across the baghouse was significantly reduced. The baghouse was operated until April 12th, when it was taken out of service during a boiler outage. Numerous operational problems with the downstream alkali scrubber, see Section 1.4.5, caused repeated setbacks and stoppage of the reverse-gas fabric filter. High pressure loss across the scrubber caused low gas flow through the fabric filter. On one occasion downstream blockages caused flue gas to be trapped in the baghouse compartments. Many other problems not related to the pilot baghouse resulted in a number of outages.

Although Elkem Technology's objective was to operate the baghouse with an air-to-cloth ratio near 4:1, it became apparent that this could not be achieved with the prevailing process conditions. Reverse-gas fabric filter operating data collected after the ducting modification is summarized in Table 5.2. In early April, the air-to-cloth ratio fluctuated from 1.1 to 3.3. Following a period of low temperature operation on April 5th, the filter drag began to increase significantly. Efforts to reduce the filter drag with sonic-assisted reverse-gas cleaning were ineffective ( a single Fuller Sonic Horn was mounted above the bag suspension mechanism in the top of each compartment). Shaking the bottom of the bags by hand improved the filter drag substantially. Based on the color of the collected fly ash, it was believed that operating the unit below the flue gas acid dew point changed the chemical composition and physical characteristics of the fly ash. While operating at high boiler loads and low excess air, i.e., at temperatures well above the flue gas acid dew point, the collected fly ash was a yellow-mustard colored fine dust. At operating temperatures below the flue gas acid dew point, the fly ash was blue and was very sticky. The precoat injection system was not reconnected during the modification of the ducting, and magnesium oxide was not used to neutralize the fly ash when operating below the flue gas acid dew point. Under normal high-load operation the fly ash appeared to be self neutralizing, i.e., the free $SO_3$ in the flue gas simply sulphated the fly ash, therefore it was believed that the intermittent use of precoat was unnecessary.

The baghouse resumed operation on May 20 for the final twelve days of the Orimulsion Test Burn. Even though the early portion of the period coincided with the co-firing of Orimulsion with natural gas, the filter drag increased from a manageable 1.9 in. $H_2O$/ft/min to an unacceptable 4.4 in. $H_2O$/ft/min by May 31, when testing was concluded. In total the reverse-gas fabric filter pilot plant accumulated approximately 1100 hour of service filtering Orimulsion fly ash.

During the 1100 hours of service there were no failures among the 80 Gore-Tex bags. Although no measurements of outlet mass emissions could be conducted, the occasional inspections by test personnel inside the baghouse compartments revealed no leakage of Orimulsion fly ash. On one occasion a bag slipped off the thimble to which is was attached and it was properly reattached. On June 24, 1991 Grubb Filtration Testing Services removed a single bag from the test unit for analysis. The bag was found to be in excellent condition with no apparent wear, and it was very clean on the outside surface. The Mullen burst strength of the used fabric was uniform throughout the bag, averaging 344 lbs/in.$_2$ (net). This represented a strength loss of 30 to 40%, compared to the nominal value of 500-600 lbs/in.$^2$ for new fabric of this type, which is a typical strength loss for "seasoned" glass fabric in a reverse-gas baghouse.

The inside surface of the bag was coated with a heavy crust of ash, which varied greatly in color, appearance, and areal density from the top to the bottom of the bag, presumably as a result of the intermittent low-load boiler upset condition and temperature gradient in the baghouse. In spite of the heavy ash loading, the average fabric permeability was in a range typically observed on reverse-gas bags from coal-fired boiler baghouses, although it varied greatly from top to bottom of the bag, corresponding to the residual ash loading, as shown in Table 5.3.

1.4.2 Pulse-Jet Fabric Filter Performance

The bags in the pilot pulse-jet fabric filter were precoated with sufficient magnesium oxide to produce a 2 in. $H_2O$ pressure drop across the bags prior to filtering Orimulsion fly ash. The oxide was thought to provide a protective layer on the clean fabric to prevent direct contact with any acidic condensation products in the flue gas during start-up and at operating temperatures near the flue gas acid dew point. During normal operation, with an air preheater outlet temperature of 390 F (full-load conditions), the pulse-jet inlet temperature averaged 350 F and the outlet temperature averaged 310 F. For the first 200 hours of operation, the automatic precoating system was set to inject magnesium oxide for two minutes every hour whenever the boiler load was below 300MW. This, it was believed, would protect the bags during times when temperatures in the baghouse compartment might be near the estimated acid dew point of 280 F. After this period it was believed that the intermittent precoat was not necessary, and that it would severely reducing the vanadium content of the collected fly ash thereby reducing its value as a vanadium ore. Therefore, the intermittent precoating was stopped.

During the first 200 hours of operation, from March 4 to March 13, 1991, the time between cleanings averaged between 45 and 60 minutes at full-load boiler conditions. For the first 100 hours of operation 3 or 4 pulses were required to reduce the pressure drop from 5 to 3 in. $H_2O$. By the end of the next 100 hours of operation 10 to 12 pulses were required for cleaning. An outage took place after 200 hours of operation and an inspection of the baghouse revealed that the hopper was full of ash. The higher pulse rate was probably due to ash re-entrainment from the hopper. Prior to the next period of operation, the hopper was emptied and the ash removal system was cleared of accumulated ash.

Inspecting the bags after about 450 hours of service revealed that the two P84 bags had failed. These were replaced with new Huyglas bags.

The pulse-jet baghouse resumed operation on April 17, but was subsequently shutdown on April 23 because the boiler began burning residual fuel oil. Pilot emission equipment operation did not resume until May 8, 1991. Baghouse performance degraded rapidly during the first 48 hours after start-up. Very sticky blue hydrated vanadyl sulphate was being formed downstream of the boiler because of low load operation. During this time the boiler was being operated at high excess air levels which produced an extraordinary amount of $SO_3$. The higher $SO_3$ concentration raised the acid dew point to about 285 F, near the temperature of the flue gas entering the pulse-jet baghouse. Pulse-jet cleaning frequency increased dramatically. There was a significant improvement in operation of the pulse-jet on the afternoon of May 10th, when high boiler load operations were resumed. However, during the following weekend, the boiler again was operated at low load, and by Sunday evening, May 12th, the pulse-jet baghouse was in continuous cleaning, and, therefore, taken out of service.

A subsequent inspection of the pulse-jet baghouse revealed that the ash removal system was plugged again. The pulse-jet was briefly operated on ambient air (May 20th) while a quantity of Visolite (BHA Group, Inc.) was fed into the inlet duct. Upon inspection of the tubesheet, a significant amount of bleedthrough of Visolite was observed on many of the Huyglas bags, especially along the top two feet of the bag length just below the tubesheet. All 48 bags were qualitatively rated based on the amount of bleedthrough of Visolite observed. The rating was either good (no bleedthrough), marginal, or poor (excessive bleedthrough). Based on these qualitative observations, 18% of the bags in row A (outer ring), 38% of the bags in row B (middle ring), and 92% of the bags in row C (inner ring) were still in good condition. Bags in good condition were such that very little or no bleedthrough of Visolite was observed on the inner surface of the bag. Bags on the outer row were in the worst condition. Two possible causes for the greater fabric deterioration on the outer row are a high pulse force during cleaning (not measured) and cooler operating temperatures because of the proximity to the outer wall of the baghouse. Three of the nine bags mounted with the Filter Guard mesh were considered to be in poor condition. On a percentage basis, however, the bags with the Filter Guard mesh fared better in their respective rows than the remaining bags (50% in row A, 67% in row B, and 100% in row C were in good condition). Following this inspection the pulse-jet baghouse remained out of service for the remainder of the Orimulsion Test Burn as the costs for replacing the bags could not be justified based on the remaining test time. In total the pilot pulse-jet fabric filter had accumulated approximately 850 hours of operation filtering Orimulsion fly ash.

Test bags sent to Grubb Filtration Testing Services for evaluation included the two P84 bags (removed on April 15th), two Ryton bags and two Tefaire bags (June 24th), and three Huyglas bags (one on May 15th and two on June 24th - one with and one without Filter Guard mesh on the cage). Of the four bag types the Tefaire bags were the only ones which exhibited no fabric degradation or wear during the test program. The P84 bags, as mentioned above, failed catastrophically after only 450 hours of service (prior to the boiler upset condition) due to total degradation of the fabric. The P84 fibers had generally discolored from their initial bright yellow to a dark bronze, however, on the outer filtration surface of the bags the fibers had become black and extremely brittle.

The failure of approximately 50% of the Huyglas bags was due to severe degradation of the fabric, especially of the fibrous batt which resulted in its delamination from the open-weave scrim support fabric. This occurred primarily near the top of the bags, where the pulse force is the greatest. Huyglas bag failures were not the result of mechanical abrasion on the cage wires, as the bags were purposely sized to achieve a tight fit on the cages. The Ryton/Rastex bags, although generally in good condition with no evidence of dust leakage, exhibited localized wear on their inner surfaces at the cage wires near the top. This wear was especially severe at the second horizontal support ring from the top of the cage. In one of the bags (B6), the felt was worn down to the Rastex scrim at several points along this ring impression. Close examination revealed incipient failures. The Ryton fiber had turned a chocolate brown color, and examination of the Ryton batt, after manual delamination from the scrim, revealed that the batt had poor tear strength. It is probable that the Rastex scrim contributed greatly to the integrity of the used Ryton/Rastex bag. Mullen burst strength comparisons on new and used fabrics are presented in Table 5.4.

The degradation of the fabrics was caused by exposure to the 350 F flue gas, which had a high moisture and $SO_x$ content, perhaps combined with operation at or below the sulfuric acid dewpoint. At least for the two Huyglas bags selected for these laboratory tests, the use of Filter Guard was not beneficial in reducing loss of fabric strength.

The areal ash density (residual ash loading) varied greatly among the different bag types and along the length of the bags (except for the Tefaire bags which were heavily loaded with ash along their length). However, the fabric permeability values in the dirty (as-received) condition were quite uniform along the length of each bag type, and they were extremely high for used bags, in the range of new fabric permeabilities. In fact, carefully washed fabric samples averaged only 4.4 cfm (13%) higher permeability than the dirty fabrics. Fabric permeability and residual ash loading data are presented in Table 5 for all fabrics except P84, for which the results were meaningless because of the massive bag failures which had occurred. Although the Huyglas bag with Filter Guard mounted on its cage had a somewhat lower residual ash loading, the permeability values for this bag were nearly identical to those for the Hyuglas bag without Filter Guard.

In summary, Telfaire was the only fabric which was sufficiently resistant to degradation during exposure to the Orimulsion flue gas and pulse-jet baghouse operation during this test. However, the Telfaire bags became much more heavily loaded with ash on their external surface and exhibited somewhat more ash penetration into the thickness of the felt than either the Ryton/Rastex or Huyglas bags. All three of these fabrics exhibited excellent filtration characteristics and extraordinarily high used-bag permeabilities. The filtration performance of the P84 felt was not able to be evaluated due to massive premature bag failures.

1.4.3 Precoat Injection System Performance

An indirect problem was encountered in operating the magnesium oxide injection system, that of lowering the flue gas inlet temperature to the baghouse. This condition resulted from the use of ambient air to transport the magnesium oxide. Although this would probably not be a big concern in a full-scale system, it is difficult to maintain high operating temperatures in pilot-scale test units because of heat loss prompted by a high system surface area/volume ratio.

A review of acid dew point related problems in the fabric filter test units and the air preheaters, strongly suggested that increased use of precoat may not provide the best solution. Two preferred alternative solutions that might be considered for a full-scale conversion to Orimulsion are: Installing air-side bypasses on the air preheaters to insure higher temperatures in the particulate control equipment and installing a dry magnesium hydroxide injection system between the economizer outlets and the airpreheater inlets to neutralize the acid in the flue gas before it is cooled in the air preheater. This latter approach has been successfully used for several years by Nova Scotia Power at their Tuffs Cove Generating Station, where high-sulphur, high-vanadium residual oil is burned.

1.4.4 Fly Ash Handling System Performance

Although the negative pressure transport system, which used heated ambient air to convey the Orimulsion fly ash from the reverse-gas fabric filter hoppers to a storage hopper, worked well, difficulty was experienced early in the test program in feeding fly ash to the transport line. Early in the test program, when the reverse-gas unit was being operated at a low under-pressure, air infiltration into the baghouse hoppers tended to fluidize the low bulk density fly ash and thereby prevent it from settling into the rotary valves. Later, when the under-pressure problem was corrected the system performed satisfactorily. A double valved lock hopper system coupled with either a positive or negative warm air transport system (operated on a predetermined timed sequence) would be preferred, in place of the rotary valve continuously operated transport system. This would lower operating and maintenance costs.

In addition, all collection and storage hopper should be heated and kept warm. Although the collection hoppers under the reverse-gas baghouse compartments were heated, the Max-Vac storage hopper was not, which caused problems in attempting to empty the storage hopper into the DustMaster mixer.

The operation of the DustMaster was less than acceptable. It was difficult to add the correct amount of water at the correct rate to fully agglomerate the fly ash. Adding about 10% to 12% water to the fly ash resulted in an exothermic hydration reaction that converted the mustard-yellow fly ash to the more familiar vanadium green. Adding too much water, e.g., 30%, produced a blackish-gray sludge that quickly curred to form a high-density solid. The best result was the production of green spheres that varied down in size from 0.25 in. Bulk density was accordingly increased from 5-10 $lbs/ft^3$ to about 45 $lbs/ft^3$, which was considerably less than the 60-65 $lbs/ft^3$ achieved at Dalhousie.

1.4.5 Aklali Scrubber Performance

Aquatech Systems, a subsidiary of Allied-Signal, Inc., was responsible for supplying both the SOXAL Process pilot plant and the alkali scrubber. The scrubber was needed to produce spent liqour to supply feedstock to the SOXAL pilot plant. Aquatech selected AirPol as the scrubber vendor and coordinated the installation and startup of the scrubber with AirPol. The objectives for this phase of the Orimulsion Test Burn are related to an evaluation of the SOXAL Process, see Section 1.4.6. However, these objectives could not be achieved without the successful operation of the alkali scrubber, which in turn could not be operated until the reverse-gas fabric filter was in service. The operation of all of these pilot-scale systems was, of course, dependant on the operation of the test boiler burning Orimulsion.

Following the startup of the reverse-gas fabric filter in March 1991, several unsuccessful attempts were made to put the alkali scrubber into service. Numerous problems hampered the startup effort. After two months most of the problems were resolved, as the scrubber was actually operated for brief periods in April. Unfortunately, there was insufficient test time remaining in the Test Burn window to achieve these objectives.

1.4.6 SOXAL Process Performance

The objectives for the evaluation of the pilot-scale SOXAL Process were:

(1) Collect process operating data to establish complete energy and material balances to determine process efficiencies. Estimate operating and maintenance costs for a full-scale commercial system, and

(2) Regenerate sufficient spent scrubber sorbent to confidently predict the probable mean-time between failures of the dipolar membranes.

Unfortunately, the difficulties experienced with the alkali scrubber, see Section 1.4.5 above, precluded a proper execution of the SOXAL test program. The information that was gathered from operating the SOXAL pilot plant was, nevertheless, encouraging.

## 1.5 SUMMARY AND CONCLUSION

The following conclusions and comments are offered as a result of the pilot-scale emissions control sytem tests, carried out as part of the Orimulsion Test Burn:

1. According to Elkem Technologies, insufficient test information was obtained to be able to provide a commercial offer, with normal guarantees, for a **reverse-gas fabric filter** having an air-to-cloth ratio of 4:1, to collect and contain Orimulsion fly ash. It is believed, that the more conventional reverse-gas baghouse, having an air-to-cloth ratio of 2:1, could be successfully used for this service, but such a design would not be cost competitive with either an ESP or pulse-jet fabric filter.

2. A low-pressure high-volume **pulse-jet fabric filter,** having an air-to-cloth ratio of 4:1, can be successfully operated down stream of a boiler burning Orimulsion, under full-load conditions, i.e., above the flue gas acid dew point temperature. Without proper protection, operation of the baghouse at temperatures below the acid dew point could result in premature degradation of the fabric filters, especially if the bag were made from Huyglas, P84, or Ryton/Rasstex fabrics. Tefaire needlefelt is apparently the preferred fabric filter material for Orimulsion service.

   If a pulse-jet fabric filter is to be considered for fly ash collection in connection with a full-scale conversion to Orimulsion, consideration should be given to installing a **backend additive system** between the economizer outlets and the air preheater inlets to neutralize flue gas acid gases, i.e., $SO_3$. Such a system would protect both the airheater from corrosion, and the baghouse from acid attack under conditions of low load and/or high excess air, where operating temperature may be below the flue gas acid dew point. Alternatively, an air-side air preheater bypass could be used to insure that the flue gas temperatures in the baghouse were never below the flue gas acid dew point. This approach may not adequately protect the air preheaters from corrosion and would have an adverse effect on boiler efficiency.

3. Fabric filter bags must be properly **precoated** with a sorbent material prior to startup, however the use of a precoat system may not be the optimum approach to protect the bags from acid attack at operating conditions below the flue gas acid dew point, see Item 2 above.

4. A lock hopper arrangement may be preferred over the use of rotary valves to transfer collected ash from baghouse or ESP hoppers to a **fly ash transport system**. The fly ash transport system can be designed for either positive or negative pressure operation with equal success. In either case it is imperative that all ash hoppers be heated and insulated to maintain the ash in a free flowing condition.

5. The operation of Mixer Systems 'DustMaster' was less than adequate in **agglomerating Orimulsion fly ash** to increase its bulk density for handling and shipping. An alternate system, which will presently by evaluated by NB Power, is offered by Ferro-Tech, Inc.

6. The **SOXAL Process**, when adequately demonstrated, may prove to be a commercially viable technology for regenerating spent FGD aklali sorbent solutions. Due to difficulties experienced in attempting to operate the aklali scrubber, the SOXAL Process could not be evaluated as part of the Orimulsion Test Burn. From the limited work carried out it is apparent that the economics of a single-membrane cell stack may be very sensitive to the excess oxygen content of the flue gas in the scrubber, i.e., the amount of sodium sulphate formed.

# 2.0 ULTIMATE FUEL ANALYSIS

## 2.1 Background

Orimulsion was delivered by tanker ship from the Orinoco region of Venezuela. Shipment sizes were generally 200,000 barrels per tanker. The Orimulsion was then transferred to tanks in Jacksonville, Florida. A barging system was used to transport the Orimulsion from Jacksonville via the St. Johns River to the Sanford Plant. Each barge carried approximately 14,000 barrels of Orimulsion. Tests of fuel were routinely performed throughout the transportation process. A typical ultimate analysis of the Orimulsion fuel is in Appendix 3.4.

**APPENDIX 3.1**

**SPECIAL COLLECTION TUBES**

FPL

**Inter-Office Correspondence**

RECEIVED

DEC 12 1990

Research & Development

**To:** Mike Guilliam

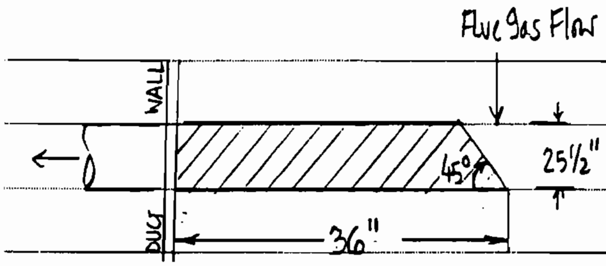
**Date:** Dec 7, 1990

**From:** Julio Alcantara

**Department:** PSN-PLT

**Subject:** ACTUAL INSTALLATION OF THE REVERSED AIR BAGHOUSE INTAKE

In reference to the attached proposed modifications for the slipstream intakes, the following configurati[on] has been partially constructed by PPM for the reversed air baghouse intake:




Reversed Air Baghouse Intake

To avoid any delay in completing the supply duct work, it was agreed to proceed with the above design. However, the pulse-jet intake will be installed as proposed in the attached memo.

copies to: M. Millares
K. Olen
J. Pugsley
M. Halpin / R. Larson
D. Erwin (PPM)

**Inter-Office Correspondence**

FPL

**To:** Mike Guilliam

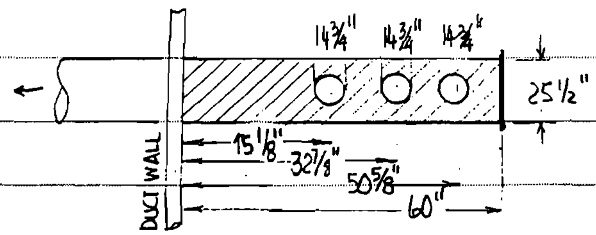
**Date:** Dec. 6, 1990

**From:** Julio Alcantara

**Department:** PSN-PLT

**Subject:** PROPOSED MODIFICATIONS FOR SLIPSTEAM INTAKES

The following drawings describe the proposed modifications for the slipsteam gas intakes:



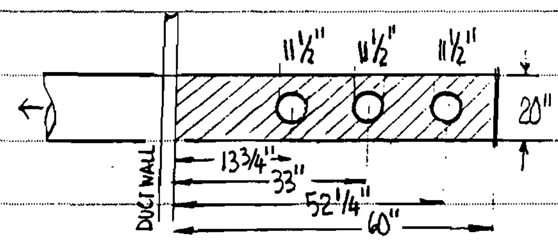

Reversed Air Baghouse Intake

Notes:

a. 14¾" Φ Holes should be installed inside the flue gas duct facing straight into the gas flow stream.

b. Intake should be blinded at the end

c. Intake should be properly secured/supported to the duct wall to avoid vibrations.




Pulse-Jet Intake

Notes:

a. 11½" Φ Holes should be installed inside the flue gas duct facing straight into the gas flow stream

b. Intake should be blinded at the end

c. Intake should be properly secured/supported to the duct wall to avoid vibrations.

Copy: M. Millares
K. Olen
J. Pugsley
M. Halpin / R. Larson
D. Erwin (PPM)

Form 1008-B (Stocked) Rev. 5/

# APPENDIX 3.2

## ECOLIAIRE REVERSE - GAS FABRIC FILTER OPERATION MANUAL

ECOLIARE ENVIRONMENTAL COMPANY

REVERSE GAS FABRIC FILTER PILOT PLANT

Operation and Maintenance Manual

Electric Power Research Institute
Florida Power and Light Company
Orimulsion Test Burn Project
Sanford Plant, Unit 4
Sanford, Florida
December 1990

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## LIST OF FIGURES

# ECOLAIRE ENVIRONMENTAL COMPANY/HOWDEN ENVIRONMENTAL SYSTEMS

## OPERATION AND MAINTENANCE SAFETY INSTRUCTIONS

The Ecolaire reverse-gas fabric filter pilot baghouse and the Howden pulse-jet pilot baghouse are not exceptionally hazardous to personnel. Appropriate safety procedures must be followed when operating this equipment. Listed below are safety guidelines these companies recommend.

1. Equipment with moving parts - dust discharge equipment, fans, mechanical shakers, etc.

   a. Isolate and lockout any power sources. This includes electrical, fluid, or any other potential power source. Tags on lockout devices should indicate the equipment is "Out of Service", the date, time, and signature of employee.
   b. Contact with the equipment should be made by qualified personnel only.
   c. Proper body protection should be worn.
   d. Allow safe access to equipment.
   e. Clearly mark area where work is being performed.
   f. Employ the use of proper and safe equipment for the removal of components.
   g. Before restarting equipment, make sure that equipment has been completely reassembled in accordance with standard practices and manufacturers recommendations.
   h. Contact appropriate personnel before restarting equipment.

2. Electrical equipment - motors, timers, solenoids, control panel, etc.

   a. Notify appropriate personnel before operating or maintaining any electrical equipment.
   b. Disengage and lockout all power disconnects before working on any component.
   c. Qualified personnel with safe and proper tool should be used when working on any electrical component.
   d. If equipment requires adjustment before reassembly, insure that involved personnel are notified.

3. Pneumatic, hydraulic and steam driven components - pneumatic operators, hydraulic operators, stem driven devices, supply and return sources, etc.

   a. Notify appropriate personnel prior to operating or maintaining any pneumatic hydraulic or steam driven components.
   b. Insure that supply and return lines have been locked out in their off position before work begins.
   c. Disconnect and lockout any associated electrical equipment.
   d. Relieve residual pressure on supply and return lines before attempting any maintenance work.
   e. Install lock out pins in valves which may open with lack of source pressure.

f. Allow adequate cool down time on any components which are at elevated temperatures.
g. Qualified personnel with proper and safe tools should perform the work.
h. Proper clearances should be granted prior to restarting any equipment.

4. Pipe, fittings, and conveyor equipment.

a. Observe all safety precautions for handling any material. Use safe lifting eqipment, follow safe practices and support equipment when in position for installation or when disconnected for repairs. Do not remove supports until this equipment is installed and secured in position by its fastners or until the equipment is in a safe location for dismantling, repair, disposal, etc.
b. Provide safe access to work area.
c. Provide warning or protection to prevent injury to personnel not involved in work being performed.
d. Provide adequate personnel protection equipment.
e. Do not work on conveyor lines when system is operating unless branch line is completely isolated.
f. Allow equipment to cool to safe temperatures before work commences.

5. Ash hoppers, tanks, storage bins.

This category includes fly ash hoppers, ash storage bins, manifolds and ductwork.

a. Never open access entry when the collecting or storage unit is filled.
b. Never open access entry to any collecting or storage unit which is under pressure unless the access is specifically designed to be used under operating conditions. Open with extreme caution using face, hands, and/or body protection.
c. Never enter a collecting or storage unit unless it is empty, cooled to a safe temperature, completely ventilated, and access or entry door blocked in the open position.
d. Never enter a collecting or storage unit alone. Have a person outside who can render assistance.
e. Never enter an unventilated unit whout adequate breathing equipment.
f. Never enter a collecting or storage unit unless all control equipment is secured in a shut-down position to prevent any material from entering the unit.
g. Before entering any collecting or storage unit, be sure that no material or equipment is overhead which could fall.
h. Provide safe entry and exit by means of secured ladders, steps, scaffolding, etc.

6. Conveyor operation.

a. Do no remove handhole covers, inspection plates, access covers, etc. from any equipment or conveyor line operating under a positive or negative pressure.

b. When a handhole cover, access door, inspection plate, poke hole, etc must be opened for rodding or clearning obstructions on conveying systems stand to one side, use face, hand and/or body protection. Exercise caution to prevent hot gas, air, or material from causing injury. Hot gas or air may be emitted during dump cycle. Sudden clearance of obstructions may cause hot ash to flow from the opening.

c. Unless specified in other instructions, do not work on equipment, open any access or inspection openings unless equipment is safely isolated or the system in shut down.

d. Install warnings or protection to prevent injury to any personnel not involved in work being performed.

e. Provide safe access to work area.

f. Exercise caution when working with spring operated equipment or installing or removing springs.

g. Exercise caution when inspecting, working on gates on receiving or separating equipment. At the end of the dump cycle, gates will close with sufficient force to cause injuries if hands are between gate and seat. At the beginning of the dump cycle, hot dusty material will be discharged.

7. General

a. Provide protection as required to prevent injuries from chains, levers, or other equipment which may extend into normal walkways.

b. Provide protection around trenches, pits, etc.

c. Keep areas clean of debris, refuse, oil, water, etc. which could cause injuries.

d. Keep area around all equipment free of obstructions and adequately ventilated to permit personnel to observe and have access to equipment.

e. Inspect all equipment, supports, braces, anchors, etc. regularly. Repair as required to prevent equipment damage or failure and injury to personnel.

f. Instruct personnel in operation of equipment and any emergency procedures.

g. Observe all plant safety regulations and safe practices for handling various types of equipment.

h. Provide safe access to all equipment.

i. Provide face, hand and body protection that may be required.

## A-1 COMPONENTS & SPECIFICATIONS

### BAGHOUSE

| | |
|---|---|
| Dimensions (approximate) | |
| Length | 42' |
| Width | 21' |
| Height | 51' |
| Number of Compartments | 4 |
| Number of bags per compartment | 36 |
| Total number of bags | 144 |
| Gross Filter Area | 6,668 sq. ft. |
| Net Filter Area (1 compt. cleaning) | 5,001 sq. ft. |
| Service Filter Area (1 compt. cleaning & isolated) | 5,001 sq. ft. |
| Air-to-cloth-ratio | |
| (gross) | 1.61:1 |
| (Net) | 2.61:1 |
| Design volume | 10,800 acfm |
| Operating temperature | |
| min/design/max | 170/500/500 |

### FILTER BAGS

By Others

### SCREW CONVEYOR SYSTEM

| | |
|---|---|
| One (1) Gather Up Conveyors | 9" dia. x 38'-0" long |
| Type | U-Trough/top loading |
| Drive Motors | 7½ HP/1800 rpm/460V/3ph/60 Hz |
| Gear reduction unit speed/conveyor speed | |

A-1 Components & Specifications (cont)

## REVERSE GAS FAN

| | |
|---|---|
| Type | Zurn-Clarage "XL" |
| Volume | 8,500 acfm |
| Fan rpm | 2282 |
| Motor hp | 30 |
| Motor rpm | 1800 |
| Static pressure @ 500°F | 12" W.C. |

## INDUCE DRAFT FAN

By Others

## SHAKER SYSTEM

| | |
|---|---|
| Type | Tubular |
| Motor hp | 1 |
| Motor rpm | 1800 |
| Shake Frequency | 300 cpm |

## ACCESS DOORS

| | |
|---|---|
| Each compartment (hinged, w/two latch) 20" x 48" | 3 |
| Each hopper (quick-opening type) 24" x 20" | 1 |

# SECTION A
## DESCRIPTION

### A-2 GENERAL

The equipment described herein filters airborne particles by the fabric filtration method. In this system, dirty gases are pulled through fabric bags which are suspended from frames located within a steel metal housing. The filtered particles are entrapped on the inside of the bags while the gases are allowed to pass through the bags and into the interconnecting duct work, where they are eventually released to the outside atmosphere. This system just described will from now on be referred to as the baghouse.

The baghouse consists of four modular compartments; one inlet manifold, one outlet manifold, one reverse gas system, one dry additive injection system and one access platform system. All these compartments are completely independent of each other, so they can be broken apart at the bolted connections and disassembled for storage or shipping to another site. An induced draft fan pulls dirty gas creating a negative pressure condition, through a central duct (dirty gas manifold) which connects to each hopper. The ceiling (tube sheet) of each hopper is the floor of each compartment and the thimble ducts interconnect the two. Refer to Figure 1 for a pictoral layout of the baghouse and a compartment cutaway.

The baghouse operates on a two phase cycle: 1) filtration, and 2) cleaning. Local operating conditions and the quality of the substance being filtered will determine the actual duration of the filtration phase, and the frequency of cleaning. During the filtration phase, dirty gas is pulled through the bags, leaving particulate on the inside of the bags; thereby, becoming "clean" gas, and passes through the primary outlet poppet valve into the clean gas manifold, where it will eventually be discharged from a stack.

A-2 General (cont)

The cleaning phase of the baghouse cycle serves to remove the filter cake from the inside of the fabric bags. It may be regarded as a cycle since there are five (5) separate sub-cycles within this phase. It is initiated by automatic timing devices that are preset within the programmable controller (located within the baghouse control panel) or by switching the system to manual control and selecting each phase of the cycle as desired. When the bags' ability to pass and filter dirty gas has been greatly reduced, as indicated by high pressure drop readings, then the cleaning phase of the cycle will be initiated automatically or may be initiated manually depending on what mode the selector switch is in, automatic or manual.

The baghouse uses the reverse gas cleaning method with redundant shake. The overall cleaning phase of the operating cycle is typically less than four (4) minutes.

The cleaning phase begins with what is referred to as the "NULL" period. This is a period of time when there is no flow of gas through the compartment. This "no flow" period permits the bags to relax which causes a certain amount of cake to release and fall from the inside of the bag. In addition, it allows a dust settling period and a transitional period before the next cleaning sub-cycle. The NULL period occurs when the clean gas valve is closed.

The reverse gas period is the next cleaning sub-cycle. At the beginning of this period, the reverse gas poppet valve opens for a preset period of time, allowing the entering reverse gas to collapse the filter bags inward causing the dust cake on the inside of the bags to break loose. The cake that has been released from the filter bags then falls into the hopper where it eventually will be discharged through a single gate tipping valve and screw conveyor system.

The reverse gas sweep poppet valve located at the end of the reverse gas manifold, allows clean gas to be continuously recirculated between the clean gas

A-2 General (cont)

and reverse gas manifolds in a "loop" fashion, by way of the reverse gas fan. At the beginning of the reverse gas period, the sweep valve is closed, and then is reopened at the end of the reverse gas period. The opening of the sweep valve allows recirculation of hot gas through the reverse gas manifold preventing the duct temperature from dropping below the dew point. The closing of the sweep valve gives the compartment a more instantaneous state of positive pressure and quicker collapsing of the bags during the reverse gas period.

The next period of the cleaning phase is "NULL 2" which is exactly the same as "NULL 1". The reverse gas valve is closed and the outlet valve remains closed so no "dirty" air flows thru the bags.

After the "NULL 2" period comes the shake period. During this period the tops of all the bags are shaken back and forth about one-half an inch total amplitude at about 300 cycles per minute. This action loosens any remaining dust cake and lets it fall to the hopper. The duration of the shake period is programmed into the programmable controller for the automatic cleaning cycle; however, if the cleaning cycle is run manaully, the duration of the shake period is as desired.

After the shake period comes another null period, "NULL 3", which is identical to the other two. No air passes thru the bags so any airborne particles left from the shake period may have a chance to settle into the hopper.

After the "NULL 3" period the compartment is brought back in service by opening the outlet poppet valve. The valve opens slowly so as air starts to move thru the bags it "reinflates" them slowly rather than instantaneously. Instantaneously reinflating the bags causes undue wear and shortens the bag life.

Figure 2, Vacuum Flow Diagram, illustrates the various poppet valve positions and the related flow of gases during these periods just described.

Industrial Clean Air

ECOLAIRE

INDUSTRIAL CLEAN AIR · P.O. BOX 5144, CONCORD, CA 94524

## VACUUM FLOW DIAGRAM

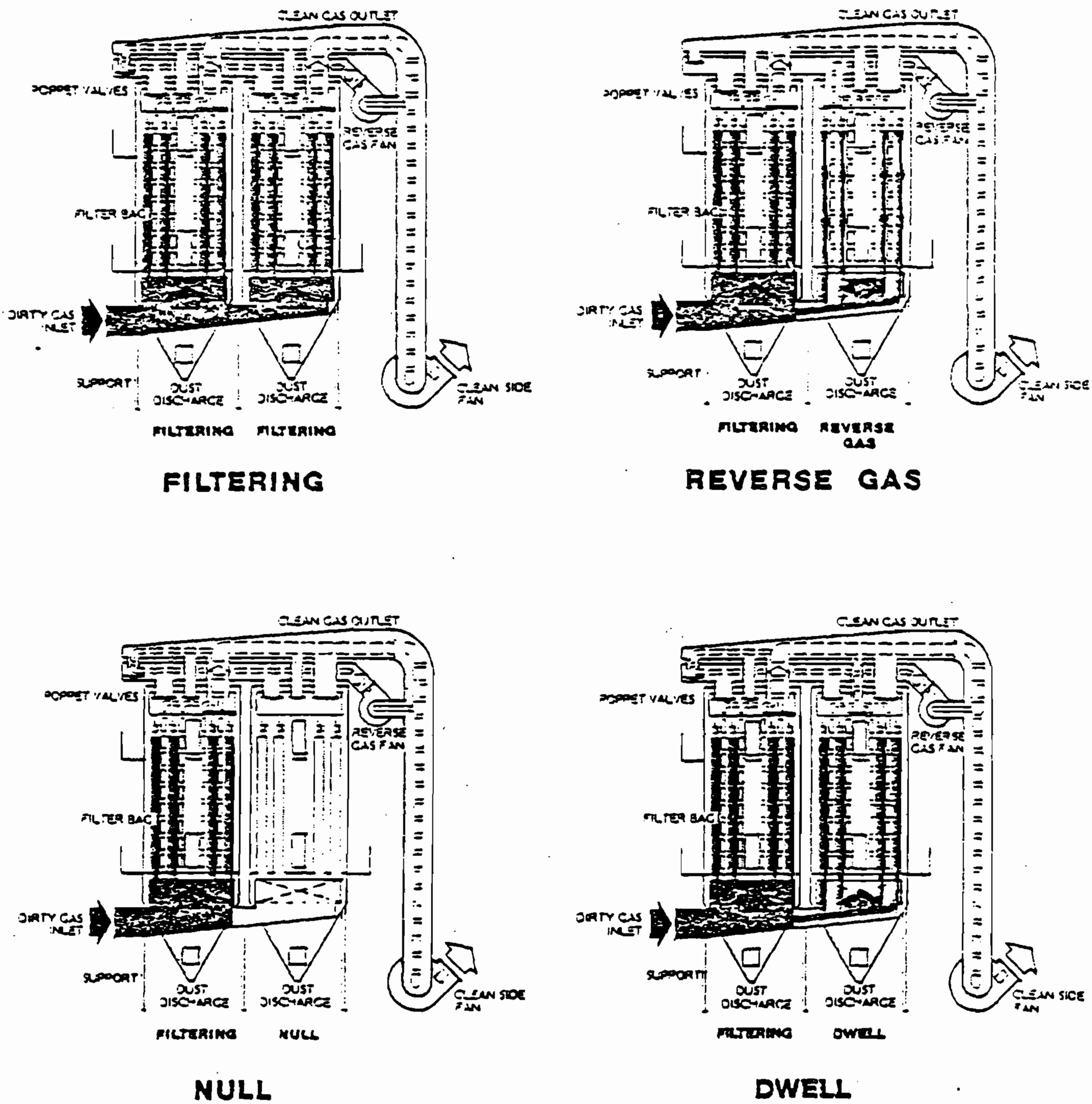



FIGURE 2

## A-3 MODULAR COMPARTMENTS

Each of the four compartments are identical in construction. They are all constructed of 3/16" thick A-36 steel plate and are structurally reinforced to withstand a static pressure of +10" w.g. or -20" w.g. There are 36 filter bags in each compartment arranged in six rows with six bags in each row. The bags are attached to open ended "thimbles", seal welded to the tube sheet at the bottom, and are suspended from tubular shaker frames at the top. There is complete access to the bags and associated hardware at both the tube sheet level and bag suspension level. At the tube sheet level there is a walkway, on all four sides of the bags, 20" wide at the sides and 17" wide at the front and back. At the bag suspension level there are two 18" wide walkways, one on each side of the six tubular shaker frames. There are three 20" x 48" quick opening compartment access doors on each compartment, one at the tube sheet level and two at the bag suspension level. These doors open outward. External walkways at both the bag suspension level and tubesheet level, with ladders from grade to the tube sheet level and from the tube sheet level to the bag suspension level, provide complete access to the compartments. Each compartment is completely insulated and lagged on all four sides and top.

## A-4 INLET MANIFOLD

The inlet manifold is designed and constructed as a totally separate component of the baghouse system that bolts to the compartments at assembly. The manifold is constructed of 3/16" A-36 steel plate and is structurally reinforced for +10 to -20" w.g. There are four 24" diameter pneumatically actuated poppet valves (see Figure 3), on the manifold, which direct "dirty" gas into each of the four compartments thru a diffuser. The diffuser distributes the dirty gas evenly under the tube sheet across the total width of the compartment. At the inlet end of the manifold are provisions for the dry additive injection system. (See Section A-8), and a baghouse preheat system (by others). A thermocouple is mounted at the inlet of the manifold to measure the temperature of the air entering the baghouse.

ECOLAIRE ENVIRONMENTAL CONTROL GROUP

A division of ECOLAIRE INCORPORATED

# TYPICAL VERTICAL POPPET VALVE ARRANGEMENT

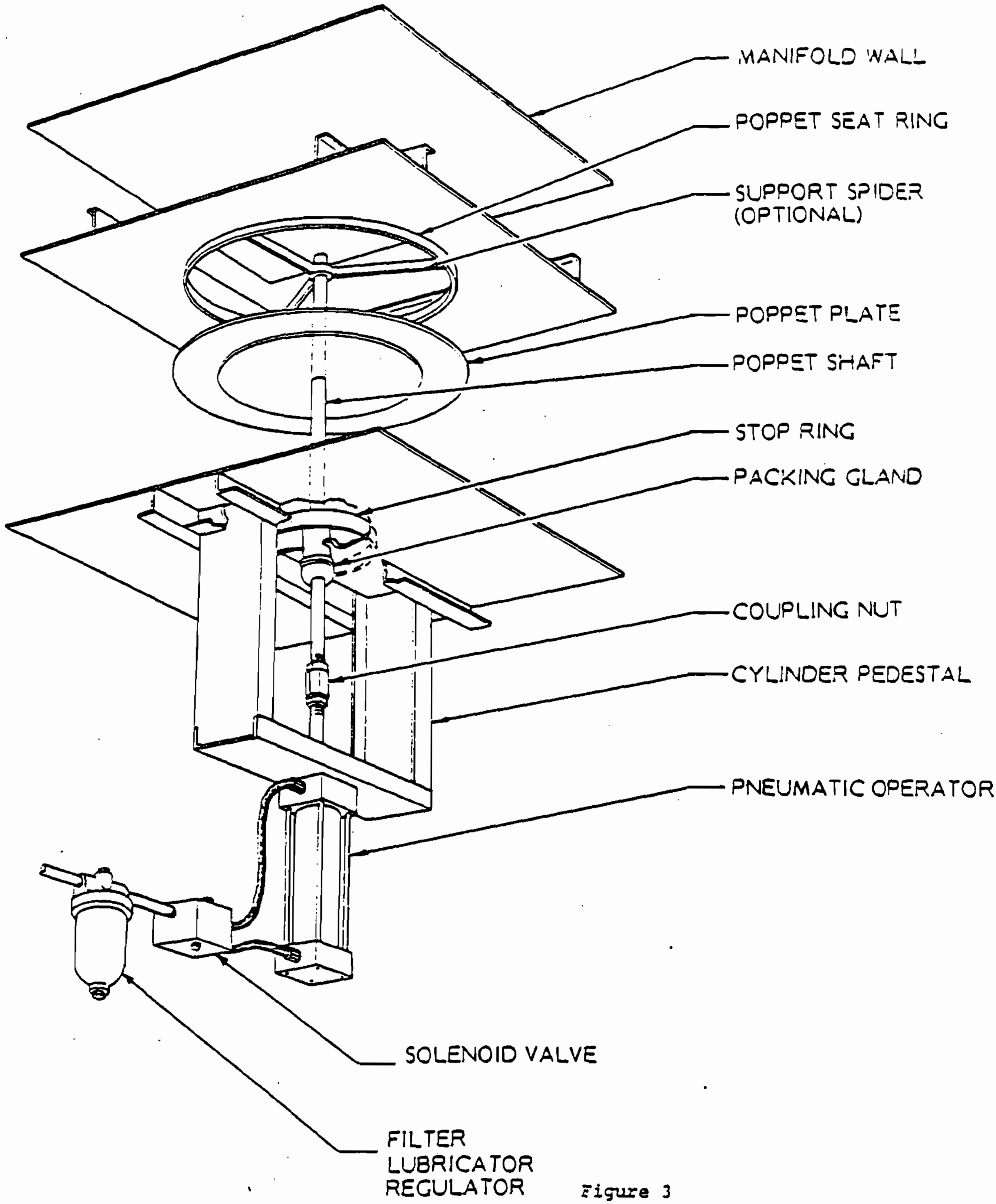



Figure 3

A-4 Inlet Manifold (cont)

Three 4" diameter test ports are located two feet upstream of each inlet poppet valve. These test ports are used for taking air samples and/or velocity measurements before each poppet valve. The test ports are spaced across the width of the manifold so as to divide the manifold cross section into three equal areas. The manifold hangs from structural members which support the tube sheet level walkway near the baghouse and are supported by columns away from the baghouse. The manifold is completely insulated and lagged.

## A-5 HOPPERS & SCREW CONVEYORS

An inverted pyramidal hopper (Figure 4) is provided at the bottom of each compartment. Hoppers collect the particle cake which falls from the filter bags during the cleaning phase of the baghouse operation. The hoppers are constructed of 3/16" thick A-36 steel plate. A three foot straight side section connects each pyramidal hopper to the bottom of each compartment. The hopper and three foot straight side section are structurally designed to hold flyash, with a 90 $lb/ft^3$ density filled to the bottom of the tube sheet. The hopper, three foot straight side section, and the compartment are all seal welded together to form one unit. A quick opening 20" x 24" access door is provided on each hopper to facilitate entry into the hopper. A 4" diameter capped poke hole and a rapping anvil are provided on opposite sides of each hopper as a means to break loose any material that may have "bridged" within the hopper or to aid the dust in falling to the lowest point in the hopper for removal. In addition, each hopper has a capacitance type high dust level probe by which a high dust level condition is detected and an alarm activated at the baghouse control panel. At the bottom of each hopper is an 8" x 8" gravity operated single gate tipping valve. The dump valve is then attached to the screw conveyor which it empties into.

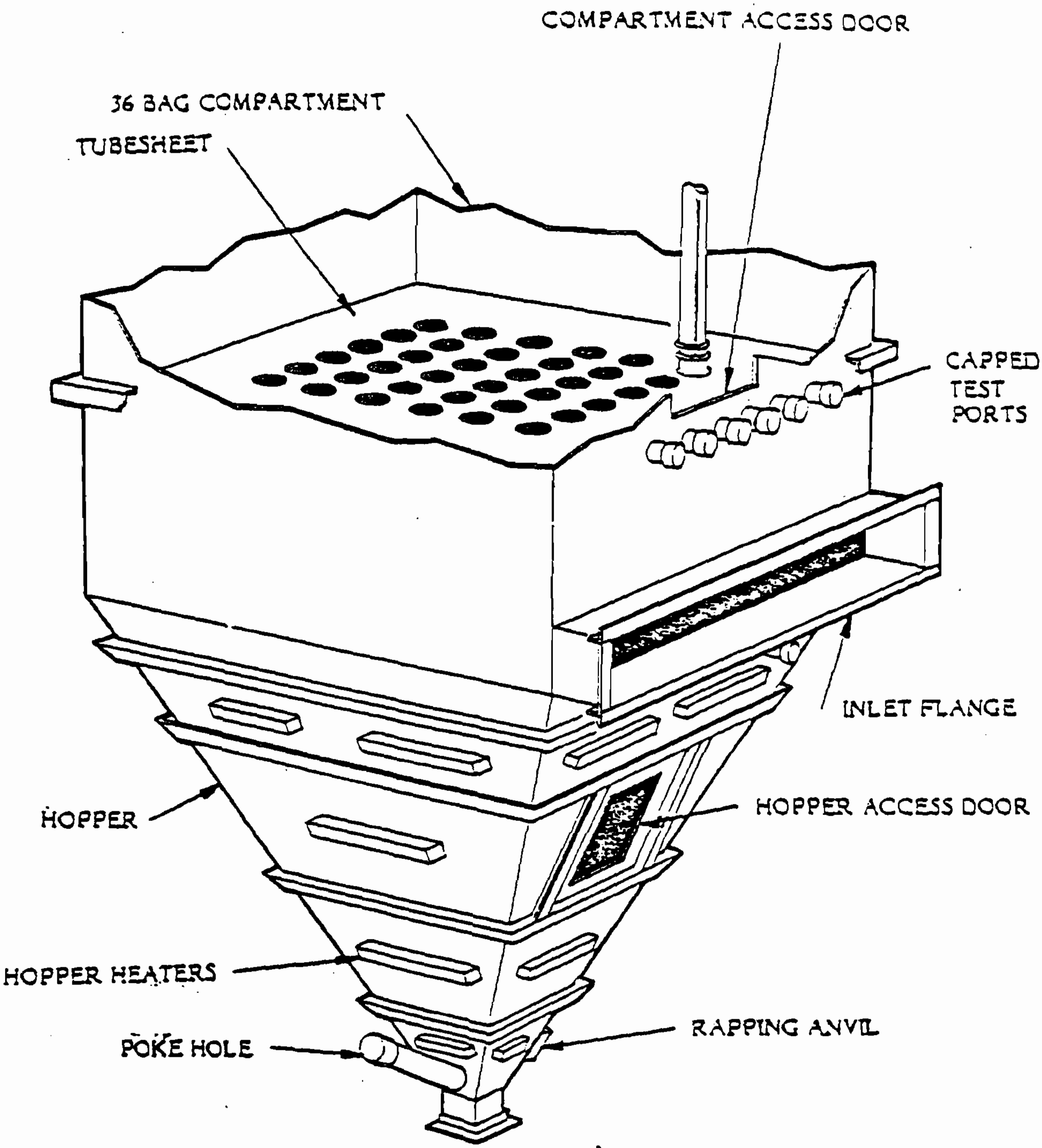



FIGURE 4 - HOPPER DIAGRAM

## A-6 COMBINATION REVERSE GAS-OUTLET MANIFOLD ASSEMBLY

The combination reverse gas-outlet manifold assembly is designed and constructed as a totally separate component of the baghouse system that bolts to the top of the compartments at assembly. It is constructed of 3/16" A-36 steel plate and is structurally reinforced for +10 to -20" w.g. There are four 24" diameter pneumatically actuated outlet poppet valves, four 18" diameter pneumatically actuated reverse gas poppet valves, and one 18" diameter pneumatically actuated sweep gas poppet valve.

The manifold assembly is connected to the top of the compartments by a rectangular duct running vertically. Half of the duct is welded to the compartment, the other half is welded to the manifold. The two pieces bolt together at the middle of the duct. The reverse gas manifold runs horizontally along one side of the vertical ducts and the outlet manifold runs horizontally along the opposite side of the vertical ducts. The reverse gas manifold, outlet manifold and the vertical ducts are all welded together to form one component.

There is one reverse gas poppet valve and one outlet poppet valve located at the top of each vertical duct. The poppet valve chambers are separated by a common wall. The reverse gas poppet valve chamber is enclosed on three sides and open to the reverse gas manifold. Reverse gas can only flow from the reverse gas manifold through the reverse gas poppet valve, down into the vertical duct and into the compartment. The outlet poppet valve chamber is enclosed on three sides and open to the outlet manifold. "Clean" gases can only flow from the compartment, up thru the vertical duct, thru the outlet poppet valve and into the outlet manifold.

The sweep gas poppet valve is located at the end of the reverse gas outlet manifold. It connects the end of the reverse gas manifold to the end of the outlet manifold. When the sweep gas poppet valve is open (when compartments are all in service), it directs the reverse gas which is not being used to clean at this time, back into the outlet manifold for recirculation. Recirculating reverse gas keeps

A-6 Combination Reverse Gas-Outlet Manifold Assembly (cont)

the reverse gas manifold hot so gases will not condense in it, leading to corrosion. At the end of the outlet manifold, opposite the sweep gas poppet valve, is a flanged connection between the outlet manifold and the reverse gas inlet duct (See Section A-7). At the same end of the reverse gas outlet manifold assembly is a flanged connection on the reverse gas outlet duct.

There are four 4" diameter capped test ports located at each of the vertical ducts. These test ports are used to take gas samples and/or velocity measurements of gas leaving the compartment. There is an access platform mounted on top of the compartments which provides access to all the test ports. Additionally, there is an access platform on top of the reverse gas outlet manifold assembly which provides access to all the poppet valves. These two platforms are connected by a ladder. There is also a ladder connecting the test port access platform to the bag suspension level platform.

The entire reverse gas-outlet manifold assembly is insulated and lagged.

A-7 REVERSE GAS SYSTEM

The reverse gas system consists of one reverse gas fan with a modulating inlet damper and manual outlet damper, one reverse gas inlet duct, and one reverse gas outlet duct. The reverse gas fan is an arrangment 1 clockwise upblast single inlet fan, V-belt driven, with the drive motor in the "X" position. The wheel is a paddle type. The fan is provided with an access door, drain, flanged inlet and outlet, inlet box, shaft seal and heat slinger. OSHA approved guards are provided for the V-belt, heat slinger and fan shaft.

The fan is driven by a 30 hp, 1800 rpm, TEFC, 460V/3ph/60Hz, 1.0 service factor motor having Class B insulation, drain breathers, grounding bolt and drain

A-7 Reverse Gas System (cont)

plugs. Also included in the motor are space heaters rated 240V and sized for operation on 120V single phase. The fan and motor are mounted on a unitary base with the motor adjustable to take up slack in the V-belts.

The inlet damper of the fan, mounted on the inlet box, is an electrically controlled modulating damper with louver blades. It is controlled with an electric actuator which receives its control signal from a controller located in the baghouse control panel.

The outlet damper is a butterfly type mounted on the fan outlet flange. It is manually controlled and is used to isolate the fan during maintenance.

The reverse gas inlet duct connects the outlet manifold of the reverse gas-outlet manifold assembly to the reverse gas fan inlet damper. There is an Annubar flow sensor located in the duct which monitors flow of gas thru the duct. The pressure transmitter on this flow sensor sends an electric signal to the control panel which will cause an alarm to sound when there is no flow of gas in this duct. The reverse gas outlet duct connects the fan outlet to the reverse gas manifold portion of the reverse gas-outlet manifold assembly. Both reverse gas inlet and outlet ducts are 18" inside diameter and are constructed of 3/16 A-36 steel. The ducts are supported from structural supports mounted on the end compartment.

The fan, inlet duct and outlet duct are completely separate components designed to bolt together at assembly. The fan, inlet duct and outlet duct are completely insulated and lagged.

## A-8 DRY ADDITIVE INJECTION SYSTEM (DAI)

The dry additive injection system is used to precoat the fabric filter bags with an additive. The additive, held in a 50 cubic foot hopper, is conveyed thru a rotary seal valve, attached to the bottom of the hopper and loaded into a screw type feed conveyor. The feed conveyor conveys the additive to a chute into which the additive is discharged. The chute is attached to a venturi nozzle. Air is blown thru the venturi nozzle by a pressure blower. The air at a high velocity, blows the additive as it drops into the chute, into a 4" diameter duct connecting the DAI to the baghouse inlet manifold. The air and additive mixture moves thru the duct and is blown into the baghouse inlet manifold where it is distributed between the compartments and eventually entrained onto the filter bags.

The DAI hopper is constructed of 14 gage mild steel plate. The hopper, as well as the rest of the DAI ports, are supported by a mild steel structural angle frame. The hopper is provided with an additive level indicator and a vibrator. The level indicator sends a signal to the DAI control panel, mounted on the DAI frame, when the additive level is low. An alarm in the DAI control panel will sound when the level is low. The vibrator vibrates the hopper while the DAI system is running. This helps the additive fall to the bottom of the hopper and keeps it from clinging to the sides.

The rotary seal valve and the feed conveyor are both driven by a variable speed controlled DC motor. The speed control is located in the DAI control panel. The DC motor is 1/2 hp, 1750 rpm, TEFC, and is coupled with a 39:1 ratio 44 rpm output gear reducer. The pressure blower produces 500 cfm of air at 42" w.g. static pressure and driven by a 7½ hp, 3600 rpm, 460V/3ph/60Hz, TEFC motor.

# SECTION B
## CONTROL SYSTEM OPERATION

### B-1 GENERAL

The baghouse control panel houses the manual and automatic cleaning controls. There are four (4) compartments in the baghouse which are cleaned sequentially. Cleaning is accomplished by the reverse gas and shake method through the timed opening and closing of individual compartment valves and the common reverse gas loop valve. (Refer to Figure 5).

Each compartment is put through a cleaning cycle made up of five (5) different periods: NULL 1, Reverse Gas, NULL 2, Shake, and NULL 3. There is a period of time between individual compartment cleaning cycles that is designated as the DWELL period. The time of each period is adjustable, using the panel-mounted Monitor Preset Terminal (MPT).

There are four (4) strip chart recorders for monitoring operating parameters: baghouse and individual compartment differential pressures, baghouse inlet and outlet temperatures, and reverse gas flow.

A 1000-word programmable controller (PC) provides all logic for system operation. All timers and counters are internal to the PC. Hand wired manual controls back up the automatic controls.

A 12-point annunciator alarms baghouse problems.

Status lights on the graphic display (See Figure 6) give indications of each valve's position, auxiliary equipment status, compartment status, and cleaning cycle position.

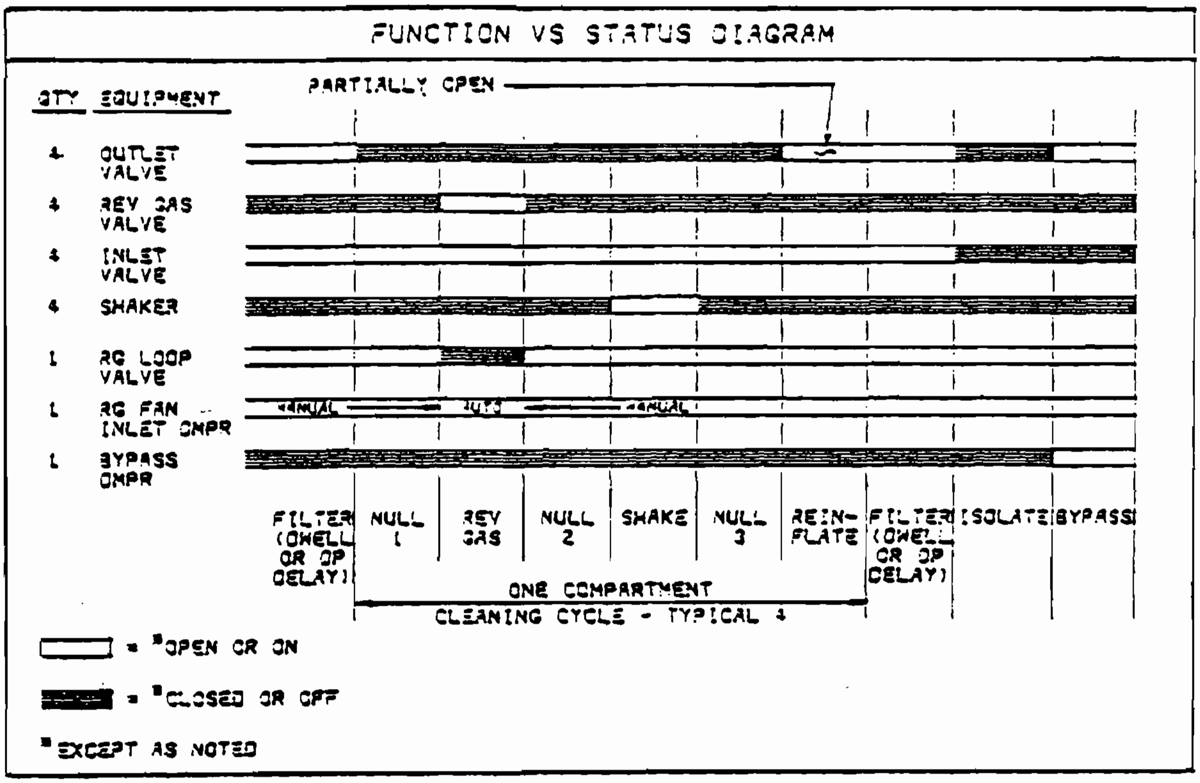



FIGURE 5 - CLEANING SEQUENCE

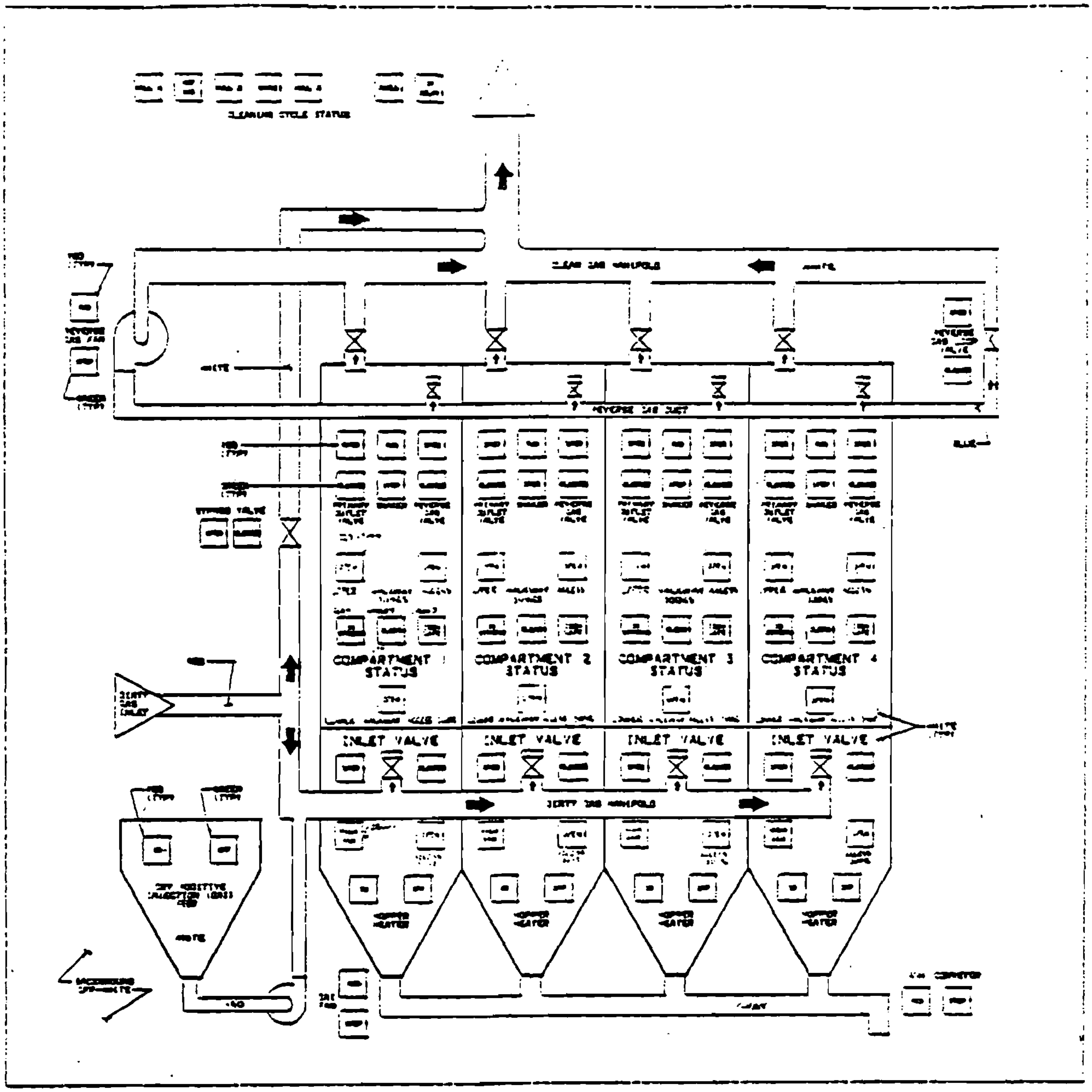



FIGURE 6 - GRAPHIC DISPLAY

B-1 General (cont)

An Auto/Manual controller is used to control the baghouse reverse gas flow by modulating the inlet damper of the reverse gas fan.

There is a U-tube manometer for each compartment on the panel face.

## B-2 CONTROL DESCRIPTION

### B-2.1 Control Power

A 15A breaker provides 120 VAC control power circuit protection. A 20A breaker provides lighting circuit protection and utility power circuit protection.

A 24 VDC, filtered, and regulated power supply provides all instrumentation and graphic light power.

### B-2.2 Cleaning Control

A three-position TIMED/OFF/D.P.-Automatic Cleaning selector switch allows selection between timer (TIMED) or differential pressure (D.P.) initiation of cleaning.

In OFF, automatic cleaning does not occur. Individual compartments may still be cleaned or isolated by using the appropriate compartment switch (see Para. B-2.3).

In TIMED auto the DWELL timer initiates the cleaning of a compartment. Five (5) other timers, NULL 1, Reverse Gas, and NULL 2, Shake and NULL 3, determine the times of their respective compartment cleaning cycle periods.

In D.P. auto the DWELL timer has no effect. Cleaning is initiated by a high alarm contact on the recorder. The five period timers still control the time

B-2.2 Cleaning Control (cont)

periods in each compartment cleaning cycle. A seventh timer, D.P. DELAY, provides a 60-second delay in between compartment cleaning cycles. Cleaning continues from compartment to compartment until all compartments are cleaned once and the initiating contact has opened. Cleaning does not resume until the high setpoint is again reached.

B-2.3 Compartment Cleaning

A three-position MANUAL-AUTO-ISOLATE selector switch is used to take a compartment out of the automatic cleaning control by switching to MANUAL or ISOLATE.

In MANUAL a compartment is placed under the control of its seven-position Auto-Null, 1-Reverse Gas-Null, 2-Shake-Null, 3-Off/Manual Clean, Null 1, Reverse Gas-Null 2, Shake-Null 3, Off, Manual Clean selector switch. The procedure for manually cleaning a compartment is as follows:

1. Place compartment MANUAL CLEAN switch in AUTO. This prevents starting in the middle of a clean cycle.

2. Place compartment control switch in MANUAL. (This energizes the compartment MANUAL CLEAN switch and immediatly stops automatic cleaning for all compartments). (The operator is cautioned to wait until auto cleaning is in DWELL or D.P. delay before attempting to manually clean a compartment).

3. Turn MANUAL CLEAN switch from AUTO to NULL 1 and time for 15-30 seconds. Next turn to REVERSE GAS and time for 15-30 seconds depending on the cleaning desired. Keep turning switch in clockwise direction at timed intervals until cleaning is completed. Repeat cycle if necessary. (Shaker will not come on unless MANUAL-OFF-AUTO switch is in MANUAL).

B-2.3 Compartment Cleaning (cont)

When all compartment control switches are in AUTO, each compartment is cleaned in sequential order by the PC. All four compartment switches and manual clean switches must be in AUTO for automatic cleaning to occur. (Shaker will not come on unless its MANUAL-OFF-AUTO switch is in AUTO).

In ISOLATE, the compartment's valves are closed, the shaker is deactivated, and all automatic cleaning stops.

CAUTION

DO NOT MANUALLY CLEAN ANY OTHER COMPARTMENT WHILE ANY OTHER ONE IS ISOLATED. THIS BAGHOUSE IS DESIGNED TO HAVE ONLY ONE COMPARTMENT OUT OF SERVICE AT A TIME, WHETHER IT IS CLEANING OR ISOLATED.

IMPORTANT

PADLOCK ALL COMPARTMENT VALVES IN CLOSED POSITION BEFORE ENTERING COMPARTMENT.

B-2.4 Reverse Gas Fan Control

The reverse gas fan is controlled by panel-mounted START/STOP pushbuttons. RUN/STOP lights on the graphic display tell whether the fan is running or not. An auxiliary START contact is a PC input and is used in the R.G. FAN FAIL alarm logic.

Control power for the reverse gas fan comes from its own control transformer in the starter. The control wiring for the fan is yellow to indicate a foreign-powered circuit per the JIC wiring color code.

## B-2.5 Reverse Gas Flow Control

The reverse gas flow is controlled through the modulation of the reverse gas fan inlet damper. An Annubar sensing device in the reverse gas manifold transforms flow into a differential pressure which is measured by a differential pressure transmitter. This field-mounted transmitter transmits a 4-20 mA signal proportional to the flow (differential pressure) to a panel-mounted integral proportional auto-manual controller. The controller compares this 4-20 mA input signal with its setpoint and transmits an open or close signal to the inlet damper positioner of the reverse gas fan. If the input signal is below the setpoint, the positioner is caused to open the inlet damper farther so as to increase the flow towards the setpoint.

If the input signal is above the setpoint, the damper is moved toward the closed position to decrease the reverse gas flow. The controller is automatically switched by the PC from manual to automatic each time a compartment goes into a reverse gas cleaning period. At the end of the reverse gas period the controller is switched back to manual in a bumpless transfer.

The reverse gas compartment poppet dampers should be allowed to open in a relatively short period of time to allow a rapid in-rush of reverse gas to enhance fabric cleaning. The valve speed is controlled by air flow control valves and should be adjusted for an air cylinder stroke velocity of approximately 3-6 inches per second.

## B-2.6 Shaker Control

Each shaker has its own 3-position MANUAL-OFF-AUTO switch. In MANUAL, the shaker is under the control of its compartments MANUAL CLEAN switch. It will now only be activated when the MANUAL CLEAN switch is in SHAKE. The shaker may be "bumped" or "jogged" by:

B-2.6 Shaker Control (cont)

1. Placing the MANUAL CLEAN switch in SHAKE.
2. The compartment control switch in MANUAL, and then,
3. Turning the shaker control switch to MANUAL from OFF in order to "jog" the shaker.

In OFF, the shaker will not respond to manual or automatic controls.

In AUTO, the shaker is solely under the control of the PC. The SHAKE and NULL 3 periods of the compartment's automatic cleaning cycle will only be included if that compartment's shaker control switch is in AUTO.

B-2.7 Dry Additive Injection (DAI) System Control

On the baghouse control panel is a two-position ON-OFF/DAI SYSTEM selector switch.

In ON, a contact closure is sent to the DAI control panel mounted near the DAI equipment. This contact is wired in series with the "Main Exhaust Fan" M.S. auxiliary contact thereby permitting the DAI system to run if the I.D. fan is running. Status lights for the hopper heater and the DAI fan are on the graphic display.

B-3 ANNUNCIATION

A 16 point annunciator performs the alarm functions. Hopper dust levels, baghouse temperatures and pressures and fans are monitored for correct operation. ANNUNCIATOR/TEST and ACKNOWLEDGE pushbuttons are used in the alarm logic.

The REVERSE GAS FAN FAILURE alarm is triggered by the PC whenever the start input to the PC is true and the N.O. MS Auxiliary Contact is not (after a one second delay).

B-3 Annunciation (cont)

The HIGH INLET TEMPERATUE alarm occurs at 500°F. The LOW INLET TEMPERATURE alarm occurs at 275°F. On either the LOW or the HIGH alarm, all four (4) inlet valves are closed immediately after the bypass damper is fully opened and remain in that position until the inlet temperature resumes an acceptable level, and the BYPASS/RESET button is pushed. The PC opens the bypass damper on either high or low inlet temperatures.

## B-4 RECORDER

A 1-pen recorder is used to record the baghouse differential pressure. It receives a 4-20 mA signal as its input. It is equipped with 2 alarm switches which are fully adjustable over the entire 0-20 W.C. range. One alarm switch is set at 6" W.C. and acts as a PC input to initiate high D.P. cleaning. The other alarm switch is set at 8" W.C. and initiates the baghouse high differential pressure alarm on the annunciator.

A 4-point recorder records each compartment's differential pressure. Its inputs are 4-20 mA signals. Its scale is 10-0-10 so as to accomodate reverse gas cleaning. Each pen is equipped with its own alarm switch. These are wired out to terminal blocks and are for the customer's use.

A 2-pen recorder records the baghouse inlet and outlet temperatures. Type "J" thermocouples are the inputs. Each pen has two alarm switches. The two alarm switches on the outlet temperature pen are wired out to terminal blocks for the customer's use.

Another 1-pen recorder receives a 4-20 mA signal corresponding to the reverse gas flow. Its scale is 0-100. This recorder is also equipped with 2 alarm switches and these are also wired out to terminals.

## B-5 GRAPHIC DISPLAY

The graphic display portrays the baghouse functions and its only purpose is to indicate those functions.

All lights activated by limit switches or other external contacts, have their "+" leads wired to terminal blocks for external connection. Thus, only a contact or switch closure external to the panel can turn these lights on, making them process dependent. 24VDC power for the lights is supplied internally.

All light sockets are mounted behind the framed graphic display on the panel face. The graphic display is hinged to open out, thus, giving access to the lights.

A GRAPHICS LIGHTS/TEST button is used to test the graphic lights with circuitry involving at least one diode per light.

## B-6 MOTOR CONTROL CENTER

The motor control center is a 480V/3 ph/60Hz, NEMA 3R enclosure made up of three vertical sections. They include:

| | |
|---|---|
| 1 | Main Breaker 250A |
| 6 | Size 1 Full Voltage Non-Reversing w/MCP |
| 1 | Size 3 Full Voltage Non-Reversing w/MCP |
| 4 | Size 1 Full Voltage Non-Reversing |
| 10 | Size 1 Control Transformers |
| 1 | Size 3 Control Transformers |
| 44 | Extra Auxiliary Interlocks - 2NO-2NC |

# SECTION C
# OPERATION

## C-1 GENERAL

There is sometimes a tendency to ignore the baghouse during start-up and operation of the boiler. This can have a detrimental effect on its life and operation. In order for the baghouse to function properly and perform as it was designed, it must be treated as an integral part of the system. EEC does not intend for these recommendations to dictate the operating procedures for the boiler. These recommendations are offered as a guide for obtaining the most efficient operating results, and EEC suggests that the procedures outlined here be incorporated into the boiler operating instructions where appropriate.

The most undesirable fumes for a baghouse occur during start-up and pre-start-up. Pre-start-up conditions include the burn-out, dry-out or refractory curing in addition to any other process where heat is generated in the heat enclosure or the connecting ductwork. There are occasions where oil soaked rags, kerosene, wood or any other easily ignited combustibles are used to produce heat. The fumes produced contain unburned hydrocarbons, aldehydes, very fine particulate, and the curing gases expelled by the refractory.

The filtering fabric is extremely sensitive to this type of gas and fumes. Rather than forming a layer of ash on the surface of the fabric, as is intended, these very fine ash particles, in combination with condensibles, can become imbedded within the mesh of the fabric. This phenomenon is known as "blinding" and results in pressure drops much greater than intended. When the bags have become "blinded," normal cleaning methods (typically reverse gas flow) will not remove the particulate from the fabric. Hence, the baghouse will continue to exhibit the undesirable symptom of high pressure drop. Start-ups and cure-outs present similar conditions which contribute to bag blinding. To avoid bag blinding

C-1 General (cont.)

new bags are commonly given a precoat of material that has been predetermined as being compatible with the filter bag and media being filtered.

Therefore, it is recommended that the filter bags not be installed until all pre-start-up operations are complete and the complete system start-up is imminent. In addition to avoiding the unnecessary exposure to fumes, the bags will also not be subjected to the normal ambient temperature fluctuations. With hot humid days and cool moist evenings, the bag temperature can drop below the dew point and become saturated with condensate. This moisture can reduce bag life and cause additional blinding.

One of the most detrimental effects that a baghouse could encounter is that of remaining in the dew point range an excessive amount of time. The chemical composition of the gas that the baghouse filters will determine how quickly and to what degree of damage the bags will encounter if the gas temperature remains in the dew point for an excessive amount of time.

A general rule to follow is to get the baghouse to maximum operating temperature as quickly as possible and keep it there for as long as possible, with a minimum amount of time in the low temperature range. Where EPA regulations permit, start-up should be conducted after preheating until normal operating temperatures are reached and preheating of the baghouse is completed. Proper start up procedures are always very important, especially during initial start up when filter bags are new. As a minimum recommendation for subsequent start-ups, it is advisable to leave a good coating of flyash on the bags by stopping the cleaning cycle one hour or so prior to shutdown. This retained flyash is then used as a precoat for the next start-up. When shutting down the baghouse, a good practice is to cool and ventilate the baghouse as rapidly as possible; again, this is to minimize the amount of time in the dew point range.

## C-2 OPERATING PROCEDURES

Six (6) check lists are provided in this section to assist prestart-up check-out, system start-up, automatic operation of the system, manual operation of the system, compartment isolation, system shut-down, and bypass operation. These lists are a minimum guide and may be incorporated with interfacing equipment control and/or operation.

### C-2.1 Prestart-Up, Check-Out

CAUTION

START-UP AND SUBSEQUENT OPERATION OF THE BAGHOUSE MUST ALWAYS BE COORDINATED WITH FACILITY PERSONNEL. PROPER SAFETY PROCEDURES SHOULD BE FOLLOWED.

NOTE: EEC realizes that this bagouse is only one part of the overall test facility. The start-up procedures herein outlined are those used and incorporated in the overall start-up of a coal-fired boiler/baghouse system. These procedures are offered as a general guideline to assist in the most effective, efficient, and safe operation of the baghouse.

| Step | Procedure |
|---|---|
| 1 | Check moisture traps in pneumatic system; drain and close. |
| NOTE: | The pneumatic system supplying compressed air to operate valves in the baghouse system must be clean and dry. If the source of the compressed air is not clean, scoring of the pneumatic operators could occur. Moreover, if moisture or condensation occurs in the air lines, freezing weather could render the valves inoperative. |
| 2 | Check lubrication units in pneumatic system; clean and fill in accordance with lubrication schedules outlined in Section D-1. |

C-2.1 Prestart-Up, Check-Out (cont)

| Step | Procedure |
|---|---|
| 3 | Check pneumatic system pressure regulator; adjust to 80 psig minimum. |
| 4 | Operate each poppet valve using the manual operator on the air cylinder solenoid valve. Adjust the speed of operation of each poppet valve to approximately 4" to 8" per second, stroking speed. Do this by way of the flow control valve located on the exhaust port of each solenoid valve. Check all poppet valve plates to insure that they are sealing properly on the seal ring. Refer to section on adjustment of poppet valves. |
| 5 | Isolation and control louver damper in ductwork to reverse gas fan inlet should be approximately one-third open. |
| 6 | Inspect all bags for proper installation. Installation procedures as dictated by the bag manufacturer shold be followed. |
| 7 | Inspect all hoppers, the screw conveyors and manifolds for construction debris or trash. |
| 8 | Make initial cycle time settings as listed below by following the directions contained in manufacturer's literature. (See Vendor Literature Section No. 2). |

NOTE: This is a nominal setting; cleaning cycle times will have to be reset when operating characteristics of the system have been established.

C-2.1 Prestart-Up. Check-Out (cont)

| Step | Procedure |
|---|---|
| 8 | (continued) |

| TIMER | CYCLE DURATION |
|---|---|
| DWELL | 60 min. |
| NULL 1 | 60 sec. |
| REVERSE GAS | 30 sec. |
| NULL 2 | 60 sec. |
| SHAKE | 15 sec. |
| NULL 3 | 60 sec. |

9 Adjust manometers on all compartments to read zero prior to start-up.

10 Check to insure that components requiring lubrication have been attended to (see Lubrication Schedule, Section D-2).

11 Check and secure all hopper, and module access doors.

12 Functionally check all moving components and allow for a "run-in period".

13 Complete precoat procedure as outlined in Section C-2.7 just prior to hot gas start-up.

## C-2.2 Start-Up

| Step | Procedure |
|---|---|
| 1 | Apply power to baghouse control power. |
| 2 | Push graphic light test button to test functioning of all graphic lights. |
| 3 | All NORMAL-ISOLATE switches turned to NORMAL. TIMED-OFF D.P. switch turned to OFF. |
| 4 | With I.D. fan inlet damper closed, turn main power to fan motor on. |
| 5 | Baghouse should be in bypass mode (if applicable) so all gases are diverted from baghouse and directed immediately to the fan and then the stack. |
| NOTE: | If baghouse had been previously shut-down because of high inlet temperature, it will be necessary to push the shut-down reset pushbutton. |
| 6 | All equipment that interfaces in some manner with the operation of the baghouse should coordinate with the start-up of the baghouse. |
| 7 | During the entrance of dirty gas to the baghouse, it is extremely important that the inlet temperature be monitored to assure that the temperature is neither too high (above 500°F) nor too low (below 275°F). If either of these conditions exist, damage may be done to the filter bags. |

C-2.3 Normal (Automatic) Operation

When the baghouse has been started and warmed up as described in Section C-2.2, automatic operation can be initiated. Refer to this Section for operating instructions.

NOTE: Automatic cleaning should only be initiated until the baghouse differential pressure has reached 3-5" w.g.

| Step | Procedure |
|---|---|
| 1 | All CLEAN-NORMAL-ISOLATE switches in NORMAL. |
| 2 | Automatic cleaning switch turned to either TIME or D.P. |
| 3 | Reverse Gas fan "ON". |
| 4 | Screw conveyor "ON". |

The baghouse is now under automatic control. If the automatic cleaning selector switch is in the "TIME" mode, cleaning will be initiated by the dwell timer. If the automatic cleaning selector switch is in the "D.P." mode, cleaning will be initiated by the predetermined setpoint activated by the differential pen on the three-pen recorder.

C-2.4 Manual Operation

As conditions dictate the need, any one of the four compartments can be isolated or cleaned manually without disturbing the automatic cleaning sequence of the other three. Once the manual clean cycle has been completed, automatic cleaning resumes with the compartment which was to be cleaned next. Manual cleaning of a compartment is initiated by turning the MANUAL-AUTO-ISOLATE switch to MANUAL.

C-2.4 Manual Operation (cont)

In isolation, initiated by turning the MANUAL-AUTO-ISOLATE selector switch to ISOLATE, all the compartment poppet valves are held in place. At no time should more than one compartment be isolated, unless auto cleaning has been turned off. Failure to do this may cause an excessive pressure drop across the baghouse. To do this turn the TIMED-OFF-D.P. automatic cleaning selector switch to off.

C-2.5 Compartment Isolation Procedures

NOTE: When operating conditions indicate that a compartment requires maintenance, or when a scheduled inspection of filter bags is required, the following procedures apply:

| Step | Procedure |
|---|---|
| NOTE: | When a compartment is isolated at the control panel, the automatic cleaning cycle for all compartments must be inoperative. Also, a manual cleaning should be initiated before isolation only if the the purpose of isolation is for bag removal. |
| 1 | Place the MANUAL-AUTO-ISOLATE switch in the ISOLATE position. This will isolate the selected compartment. |
| 2 | Lock-out all poppet valves for the selected compartment. |
| 3 | First open the upper compartment access door; then open the lower access door. Allow for a suitable cool down period before entering a module for maintenance or inspection. |

C-2.5 Compartment Isolation Procedures (cont)

NOTE: Follow proper safety procedures when entering isolated modules.

| Step | Procedure |
|---|---|
| 4 | Close and seal compartment doors when maintenance and inspection is complete. |
| 5 | Remove all mechanical lock-outs from poppet valves. |
| 6 | Return MANUAL-AUTO-ISOLATE switch to AUTO position. This will automatically place isolated module back on stream and in the normal filtration mode. Return TIMED-OFF-D.P. switch to timed or D.P. This will automatically place the baghouse back on the automatic cleaning cycle. |

C-2.6 Shut-Down Procedures

| Step | Procedure |
|---|---|
| 1 | Turn off automatic cleaning cycle one hour prior to shutting down the baghouse. This will leave a protective coating of fly ash dust on the bags at shutdown, and hence, already precoated for the next start-up. |
| 2 | Ventilate the baghouse by first opening the upper access doors and then the lower access doors on all modules. With the I.D. fan on and the inlet damper slightly open, run the fan for a length of time that will allow all the gases to be replaced by ambient air to sufficiently ventilate the baghouse. |

C-2.6 Shut-Down Procedures

| Step | Procedure |
|---|---|
| 3 | Empty all ash from hoppers and screw conveyor. |
| 4 | If the baghouse is to be shut down for an extended period, electrical power and facility air should be shut off. |

C-2.7 Precoat Procedures

IMPORTANT

ALL COAL FIRED BOILER FABRIC FILTERS ARE TO BE PRECOAT$ED WITH FLY ASH HAVING THE SAME OR SIMILAR CHARACTERISTICS TO THE FLY ASH TO BE FILTERED.

Method One

If the system contains a bypass or other method to limit flow to the fabric filter during start-up, and the authorities will allow it, the fabric filter can be slowly brought on line precoating with the fly ash in the flue gas. It is important that the boiler is burning 100% coal during the precoating procedure. The compartment inlet dampers or I.D. fan dampers can be used to restrict flow. Flow should be gradually increased over a two-hour period. The cleaning cycle should be disconnected until the fabric pressure loss reaches 3-4" w.g.

Method Two

In the event the fabric filter must ventilate the boiler while oil is being fired during start-up, an external source of fly ash must be used. See note above. Precoating can be accomplished using the same method as for metallurgical and

C-2.7 Precoat Procedures (cont)

combustion processes except flue gas flow should be gradually increased as explained in Method One.

CAUTION

VIRGIN FABRIC OR FABRIC WITH INADEQUATE ASH CAKE MUST NOT BE EXPOSED TO OIL FIRED FLUE GAS. CARE MUST BE EXERCISED WHEN GRADUALLY INCREASING FLUE GAS FLOW TO INSURE THE GASES TO THE FILTER ARE ABOVE THE DEWPOINT WITHIN 30 MINUTES OF INITIATION OF GAS FLOW.

# SECTION D

## MAINTENANCE

### D-1 GENERAL

This section provides instructions for periodic inspection and lubrication, troubleshooting, and replacement of those parts listed in Section E. Section D-2 lists inspections and lubrication procedures which should be followed to assure proper operation of the baghouse and minimize time spent on baghouse repair.

### D-2 PERIODIC INSPECTION, MAINTENANCE, AND LUBRICATION

| Interval | Procedure |
|---|---|
| Daily | ~~Check stack daily, or at start of each shift, for evidence of smoke. If smoke is visible, locate the faulty module by initiating an automatic cleaning cycle. When smoke stops, isolate faulty compartment and replace filter bags (Paragraph G-3.1).~~ Tour lower and upper levels of baghouse and inspect visible components for good condition and cleanliness. Inspect pressure gauge on air supply control unit. If pressure varies more than 10 psi from the required 80 psi and adjustment of regulator will not correct the condition, notify facility maintenance personnel. At control panel, check to make certain there are no burned out bulbs. ~~Check manometers for normal operating differential pressure (this would be based upon previous operating conditions).~~ |
| Weekly | Inspect reverse air fan pillow block bearings and apply lubrication if necessary. Inspect fan belt tensions and adjust if necessary. At air |

D-2 Periodic Inspection, Maintenance, and Lubrication (cont)

| Interval | Procedure |
|---|---|
| Weekly (cont) | |
| | supply control unit, drain any accumulated water from filter; check oil level in lube unit and add oil if necessary. Check packing on poppet damper shafts for leaks, tighten cap and replace packing as required. |
| Monthly (or as required) | Initiate a compartment maintenance condition (isolate), one compartment at a time, and inspect bag tension at upper level and bag clamping at lower level. Bags should be properly suspended with no evidence of leakage around cap or wedge-lock. Inspect bags for evidence of wear, particularly around stiffener rings. Replace damaged bags or attaching parts as required. Check for evidence of condensation in each module. Inspect gaskets around all module and hopper access doors and replace gaskets if necessary. Use a feeler gauge and inspect gaps between poppet plates and seats on manifold for excessive clearance. |
| Yearly | Make certain mounting bolts and bearing retainer cap bolts on reverse gas fans are secure. Check fan shaft play within bearings and replace bearings or shaft as required. Inspect exposed structure and walkways for evidence of rust or corrosion; clean and repaint if necessary. Inspect all welds and ducting for damage that may affect baghouse operation and repair if necessary. |
| 36 Months | Shutdown baghouse and thoroughly inspect all parts and components. Replace defective parts or components as required. |

D-2.1 Filter Bag Installation

CAUTION

USE PROPER SAFETY PROCEDURES WHEN REPLACING FILTER BAGS

NOTE: Follow those procedures as dictated by the appropriate bag manufacturer. Refer to Figure 7 for installation and removal instructions.

D-2.2 Removal of Air Cylinder, Limit Switches, & Solenoid Valve Ass'y

NOTE: Limit switches, solenoid valves and air cylinders are assembled as a single unit. If replacement of any of these parts is required, the entire assembly must be removed first.

a. If conditions permit, shutdown baghouse as described in Section C-2.5, or, if baghouse operation must continue, isolate malfunctioning modules.
b. Close valve on air supply serving the isolated modules, and make certain pressure in supply line has been adequately relieved.
c. Disconnect control wiring from terminal block inside junction box mounted on air cylinder. Disconnect flexible conduit from junction box.
d. Disconnect air supply line from solenoid valve.
e. Manually retract piston rod and loosen two jam nuts securing connector between cylinder piston rod and poppet shaft.
f. Rotate connector until piston rod is separated from poppet shaft.
g. Remove four bolts securing cylinder to flange on cylinder pedestal and detach cylinder.

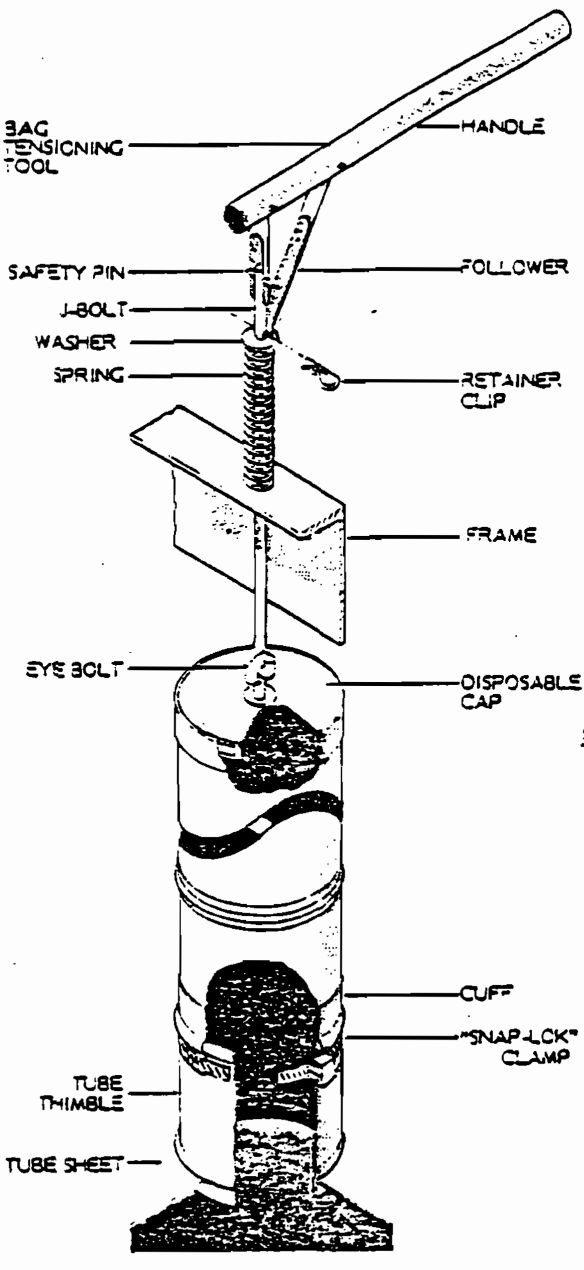
ECOLAIRE ENVIRONMENTAL CONTROL GROUP

T-0506

380 CIVIC DRIVE PLEASANT HILL CA 94523

a division of
ECOLAIRE INCORPORATED

# BAG HANGING DIAGRAM
# "CLAMP TYPE"




| STEP | TO HANG BAGS: |
| --- | --- |
| 1 | Position the bag in its shipping container at the lower level near the area where the bag is to be suspended. |
| 2 | Lower a cord with a hook on it from the upper walkway, and hook it through the eye bolt on the cap. |
| 3 | Carefully guide and inspect the bag as it is pulled out of its shipping container and up to the frame, and hook the eye bolt on the J-bolt. |
| 4 | Holding the bag cuff with the sewing seam towards the walkway, guide the cuff over the thimble. Place the clamp around the cuff and tighten loosely. Adjust the two of them so that the rope bead of the cuff is just below the bottom edge of the clamp. Then move clamp and cuff together until the top edge of the clamp is just under the bead of the thimble. Make sure that the clamp and cuff are level on the thimble. The vertical seam in the filter bag must not be twisted.<br><br>When installing glass bags, be sure not to apply a stretching thumb pressure on both sides of the vertical seam. This may separate the glass yarn and eventually cause bag failure. |
| 5 | Extend the "J" bolt to its lowest position by moving the hair-pin retainer clip to its last hole. |
| 6 | Hook the bag tensioning tool under the safety pin and place follower against the "J" bolt above the washer. |
| 7 | Push the handle of the bag tensioning tool down until the spring has been compressed two inches and hold it there. |
| 8 | Move the hairpin retainer clip to the nearest hole above the washer and slowly release the bag tensioning tool. |

| STEP | TO REMOVE BAGS: |
| --- | --- |
| 1 | Hook the bag tensioning tool under the safety pin at the top of the "J" bolt, and place follower on the washer above the spring. Make sure the follower presses against the "J" bolt. |
| 2 | Push down on the bag tensioning tool handle until the hairpin retainer clip can be removed. |
| 3 | Remove the hairpin retainer clip and place it in the top hole of the "J" bolt next to the safety pin. |
| 4 | Slowly release the tension on the spring and remove the bag tensioning tool. |
| 5 | Shake bag gently to allow any excess dust inside bag to fall into the hopper. Remove clamp. Place end of bag into container; this will minimize clean up time. |
| 6 | Using the cord and hook secured to the bag cap, lift bag cap from "J" bolt and slowly lower bag downward as the lower end is being fitted into the container. |
| 7 | Tie end of cord to frame at upper walkway level and allow cord to hang until replacement bag is ready to be installed. |
| 8 | Inspect "J" bolt tensioning spring and washer for good condition and replace if necessary. Vacuum area before installing new bag. |

FIGURE 7

## D-2.3 Installation of Air Cylinder, Limit Switches & Solenoid Valve Ass'y

a. With cylinder piston rod retracted, secure cylinder base to flange on mounting pedestal with four bolts and washers.

b. Thread jam nut on end of piston rod, and jam nut and connector as far as they will go on poppet valve stem.

c. Secure stem to piston rod by threading connector onto rod.

d. Manually actuate piston rod and attached stem until piston rod is fully extended.

e. Adjust poppet valve assembly until proper deflection of poppet seal plate is accomplished. (See Section D-2.4)

f. Without changing position of connector, tighten jam nut down securely against connector to prevent any change in stroke length.

g. Connect flexible conduit to junction box on air cylinder.

h. Connect control wiring to correct terminals in junction box.

i. Connect air supply line to solenoid valve using care to prevent overtightening.

j. Open valve on air supply control unit and adjust regulator so that pressure gauge reads 80 psi, and remove poppet stem locking bars to permit operation of damper plates.

## D-2.4 Adjustment of Poppet Valve

Adjustment of the poppet valve may be required prior to start up, during operation, or when maintenance is being performed on poppet valve components. This adjustment can be made without taking a module out of service.

D-2.4 Adjustment of Poppet Valve

| Step | Procedure |
|---|---|
| 1 | Loosen jam nut(s) on poppet and cylinder shaft. |
| 2 | Manually stroke cylinder to the extended position. |
| 3 | If the cylinder is understroking, lengthen stroke by rotating cylinder shaft in a clockwise direction until contact is made with seal ring. |
| 4 | Retract cylinder shaft with manual operator. |
| 5 | Lengthen stroke further according to values below: |

| | |
|---|---|
| Inlet Poppet | 1/2" |
| Outlet Poppet | 1/2" |
| Reverse Gas Poppet | 3/8" |
| Sweep Gas Poppet | 3/8" |

| Step | Procedure |
|---|---|
| 6 | Extend cylinder shaft, watch for contact with seal ring and deflection of poppet valve assembly after seal ring contact is made. |
| 7 | If cylinder is overstroking, the following conditions may exist: (1) constant exhausting of air from speed control device on solenoid when valve is in closed position; (2) excessive deflection on poppet valve assembly when contact with seal ring is made. |
| 8 | Retract cylinder shaft. |

D-2.4 Adjustment of Poppet Valve (cont)

| Step | Procedure |
|---|---|
| 9 | Rotate cylinder shaft in counter clockwise direction while holding Garlock connecting nut. Proceed in 1/2" increments until proper deflection is experienced (poppet plate should deflect per valves in Step Five). |

D-2.5 Replacing, Repairing or Installing Reverse Gas Fan Components

(Refer to Vendor Literature, Section 14, for Instructions)

# SECTION E

## TROUBLESHOOTING

### E-1 BAGHOUSE MALFUNCTIONS

Equipment Category
(Reverse Gas)

| Sympton | Cause | Remedy |
|---|---|---|
| 1. High baghouse pressure drop. | Bag cleaning mechanism not adjusted properly. | Shorten dwell timer. Increase reverse gas timer. Increase volume from reverse gas fan. |
| | Reverse gas pressure too low. | Increase reverse gas damper openings. Check for leaks on reverse gas manifold. Check poppet valve seals. Check for leaking bags. |
| | Reverse gas pressure too high. | Decrease reverse gas damper opening. Check bag tension. |
| | Internal timer failure. | Consult manufacturer's Field Service Department. |
| | Bags unable to release cake—often due to condensation in baghouse. | Consult manufacturer's Field Service Department. |
| | Incorrect differential pressure reading. | Clean out pressure taps to manometers. Reset gauges to zero. |
| 2. Low amperage on reverse gas fan motor/low air volume. | Reverse gas fan inlet damper closed. | Increase damper opening until correct amperage achieved. |
| | Belt slipping or broken. | Check for broken belts, tension and adjustments. |

E-1 Baghouse Malfunctions (cont.)

| Sympton | Cause | Remedy |
|---|---|---|
| 3. Dirty discharge at stack. | Bags leaking. | Isolate leaking compartment if possible without upsetting system. Check for signs of dust deposits on tube sheet and walls (this indicates leaking bag).<br><br>If problem persists, contact manufacturer's Field Service Department. |
| 4. Excessive wear on reverse gas fan. | | Consult manufacturer's Field Service Department. |
| 5. Excessive vibration of reverse gas fan. | Bearing worn, bearings loose, fan wheel loaded. | Replace bearings. Tighten bearings. Check for broken bags. Clean and inspect wheel. |
| 5. Poor pneumatic valve actuation. | Low station air pressure. | Check outlet pressure from air compressor. Check for air line restriction. Check for leaks in system. |
| 7. Excessive wear on screw conveyor. | | Consult manufacturer's Field Service Department. |
| 8. Excessive wear on screw conveyor. | | Consult manufacturer's Field Service Department. |
| 9. Insufficient compressed air. | Compressed air consumption too high. | Check out air compressor as above. |
| 10. Premature bag failure/decompositon. | | Consult manufacturer's Field Service Department. |
| 11. Moisture in baghouse. | | Consult manufacturer's Field Service Department. |

Names and Telephone Numbers

Joy Environmental Systems (Ecolaire)
Mr. Bob Meredith - 206/228-3228
Mr. Leland Kallmeyer - 215/648-8676

Southern Research Institute
Mr. Ken Cushing - 205/581-2381
Mr. Vann Bush - 205/581-2269
Mr. Mike Robinson - 205/581-2605
FAX - 205/581-2448

ADA Technologies
Ms. Jean Bustard - 303/792-5615
Mr. Rick Slye - 303/792-5615

Electric Power Research Institute
Dr. Ramsay Chang - 415/855-2535
FAX - 415/855-2954

## APPENDIX 3.3

## ALKALI SCRUBBER OPERATION MANUAL

OPERATING CONDITIONS

| | |
|---|---|
| Gas Inlet Volume | 8,590 ACFM |
| Gas Inlet Temperature | 390°F |
| Water Vapor Content (vol.) | 14.6% |
| Gas Outlet Volume | 6,884 ACFM |
| Gas Outlet Temperature | 145°F |
| Liquid Rate | |
| Recirculate, each stage | 150 GPM |
| Bleed | 2.4 GPM |
| Evaporate | 2.7 GPM |
| Chemical Make-Up | 2.1 GPM |
| Water Make-Up | 3 GPM |
| Mist Eliminator Wash | 16 GPM (intermittent) |
| Pressure Drop | 6 in. w.g. |
| SO2 Rate | |
| Inlet | 2400 PPMvd |
| Outlet | 120 PPMvd |
| pH 1st. Stage/2nd stage | 5.5 - 6.0/6.8 - 7.0 |

Item #1 One (1) AirPol Two-Stage SO2 Absorber, consisting of the following:

Two-Stage Packed Tower, constructed of 11 ga. 316L S.S. with overall dimensions of 4'-6" dia. by approximately 38' overall height. Vessel has two packed sections, each 5' high, with space allowed for 1' additional packing for each bed, cone baffle and trough for separate liquid loops for each section. Packing is 2" 316 S.S., Nutter Rings or equal, with S.S. grid support plate and retractable spray header, and 1st. stage wash header. Second Stage section has 316L S.S. chevron mist eliminator with wash header for intermittent wash. Vessel has integral recycle section and all necessary pipe and instrument connections, and four (4) 20" manholes plus two (2) 12" handholes for removal of packing.

Item #2 Two (2) Manually operated butterfly dampers, 2'-2" dia., 316L S.S. construction in extended spool piece with blank-off plates located at inlet and outlet of scrubber.

| | |
|---|---|
| Item #3 One (1) | Lot of Ladders & Platforms for $SO_2$ Absorber providing access to all manholes and outlet damper. Item incldues heay duty grating, 1-1/4" pipe handrails, caged ladder, carbon steel construction with rust inhibitive shop primer. |
| Item #4 One (1) | Recycle Tank 400-gallon capacity, 3'-10" dia. x 5'-10" high, with cover, vent, 10" dia. inspection port, all necessary liquid and instrument connections, constructed of high density polyethylene. |

Item #5 One (1) Lot Instrumentation consisting of the following:

a) Two (2) Liquid level DP cells, transmitters indicator/controllers, high and low alarms.

b) Three (3) temperature elements, transmitters and indicators.

c) One (1) Density element, transmitter, indicator/controller

d) Two (2) pH probes, transmitters and indicators.

e) Differential Pressure Transmitter and indicator across scrubber

f) Four (3) magnehelic gages

g) Two (2) Flow elements, transmitters and indicators with low level alarm.

h) One timer and solenoid valve

i) All required pressure gages for piping

j) One (1) Instrument control panel, NEMA 12, combination control/MCC panel, approx. 6'x6'x18" with flange mounted disconnect/ Main CB, complete with 5 open starters with CB's, each with start/stop and running lights. Panel also contains reliance automatic PLC and AC and DC terminal strips. All controllers, indicators and recorders are panel mounted. PLC logics used for annunciator system. Junction boxes are located on skid.

Item #6 One (1) Lot of Pumps with motors, 316 S.S. centrifugal type, consisting of the following:

| No. | Type | GPM | S.G. | Ft.Hd | BHP | Motor HP |
|---|---|---|---|---|---|---|
| 2 | Recycle | 150 | 1.26 | 75 | 5.5 | 7.5 |
| 1 | M.U.Water | 20 | 1.0 | 60 | 0.6 | 3.0 |

Motors are tropical washdown type, 50°C rise.

Item #7 Two (2) Sets of Dual Filters, totaling 4 filter assemblies, Cuno Model 6SL4 or equal, each filter assembly consisting of the following:

a) Water tight 316 S.s. housing

b) Swing bolt cover plate

c) Support legs

d) 150 psi ASME Code construction (not stamped)

e) Six (6) quadruple length, 1 micron rating, polypropylene cartridge filters. Also included are 100 spare cartridges.

Item #8 One (1) Skid, with all necessary channels and angles to support the equipment, carbon steel construction, sandblasted and 2-coat Imron 62 polyurethane primer and Imron 326 enamel. All equipment will be assembled as much as possible on the skid for proper fit, match-marked and disassembled for shipment.

Item #9 One (1) Liquid Retaining Pan, to extend across bottom of skid, with 5" high side walls, constructed of 11 ga. 316L S.S., with one spring loaded S.S. valve and one manual valve.

Item #10 One (1) $SO_2$ Analyzer, Dupont Model 460 or equal, to measure $SO_2$ at two sampling points with ranges of 0-300 and 0-3000 PPM. Unit includes sample probes, heated canister in external heated box, 2-pen strip chart recorder and all required 1/4" teflon tubing.

Note: Weight of complete system, as shipped......13,600 lbs.
Operating weight of complete system........24,100 lbs.

## APPENDIX 3.4

## ORIMULSION ULTIMATE ANALYSIS

FPL

**Inter-Office Correspondence**

| | | | |
|---|---|---|---|
| To: | Ray Schweikart | Date: | November 13, 1991 |
| From: | Kevin O'Donnell | Department: | Central Laboratory - JPS/LAB |
| Subject: | **ULTIMATE ANALYSIS OF ORIMULSION FUEL BURNED AT SANFORD PLANT** | | |

Per your request, attached is a typical ultimate analysis of the Orimulsion fuel (Delivery #4) used at our Sanford Plant, Unit #4. If you need additional information, feel free to contact me at 640-2020.

K. M. O'Donnell

K. M. O'Donnell
Manager - Central Laboratory

KMO/mm

Attachment

POWER RESOURCES CENTRAL LABORATORY
FLORIDA POWER AND LIGHT COMPANY
STATE OF FLORIDA LABORATORY CERTIFICATION NUMBERS:
DRINKING WATER CERTIFICATION NUMBER: 56275
ENVIRONMENTAL CHEMISTRY CERTIFICATION NUMBER: E56078

AS-RECEIVED - PSN ORIMULSION

VESSEL: ONDA CHIARA (DELIVERY #4)

DATE COLL'D: 03-08-91 DATE REC'D: 03-09-91 DATE REPORTED: 03-13-91

| | ANALYTICAL METHOD | VOLUMETRIC SHIP COMPOSITE |
|---|---|---|
| DENSITY @60F, g/cm3 | (ASTM D-4052) | 1.0076 |
| DENSITY @60F, lbs/BBL | | 353.161 |
| BTU/LB | (ASTM D-240) | 12964 |
| MBTU/BBL | | 4578 |
| MBTU/TON | | 25928 |
| % SULFUR | (ASTM D-1552) | 2.6 |
| VISCOSITY @ 31.3C, mPAS SHEAR RATE = 139.1 | (ASTM D-4684) | 587 |
| % WATER | (ASTM D-95) | 32 |
| % SEDIMENT | (ASTM D-473) | 0.27 |
| % ASH | (ASTM D-482) | 0.14 |
| % ASPHALTENES | (IP-143) | 7.8 |
| VANADIUM (MG/KG) | | 266 |
| SODIUM (MG/KG) | | 83 |
| IRON (MG/KG) | | 5 |
| NICKEL (MG/KG) | | 69 |
| MAGNESIUM (MG/KG) | | 309 |
| POUR POINT, F | | 33 |
| SO2 (LBS/MILLION BTU) | | 4.0 |
| % CARBON, (BY WEIGHT) | | 60.31 |
| % HYDROGEN, (BY WEIGHT) | | 7.03 |
| % NITROGEN, (BY WEIGHT) | | 0.50 * |
| % OXYGEN, (BY DIFFERENCE) | | 0.02 |

COMMENTS: * ANALYZED BY SCHWARKZOPF LABORATORY.

COPIES TO:

| | |
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| M. MILLARES, JPE/EDO | E. CALLANDER, FR/GO |

ANALYZED BY: J. Uzra / Y. Harrison

CERTIFIED BY: K. M. O'Donnell

DATE: 3/18/91

APPENDIX 3.5

SRI PROGRESS REPORTS

Southern Research Institute

March 20, 1991

Dr. Ramsay Chang
Project Manager
Electric Power Research Institute
P.O. Box 10412
Palo Alto, CA 94303

**Subject: RP3803-10, Pulse-Jet Baghouse Laboratory Support Work**
**Progress Narrative No. 3, FP&L Orimulsion Project**

Dear Ramsay:

The two fabric filter pilot plants located at Florida Power & Light's Sanford Unit 4 Orimulsion Project began operation during the week of March 4, 1991. The Howden Pulse-Jet Pilot Baghouse (PJFF) began operation on March 4, 1991. The Ecolaire Reverse-Gas Pilot Baghouse (RGFF) began operation on March 6, 1991. Because of problems with the reverse-gas fan, the RGFF was shut down on March 12, 1991. The PJFF was shut down on March 13, 1991 prior to an outage at the host boiler. It is anticipated that the host boiler and the PJFF and RGFF will resume operation by March 26, 1991. The current Orimulsion Project schedule requires that use of orimulsion as a fuel at Sanford Unit 4 cease after May 31, 1991. The following sections provide a brief description of activities related to baghouse startup.

Howden Pulse-Jet Pilot Baghouse (PJFF)

The Howden Pulse-Jet Pilot Baghouse was installed by Mr. Michael Kelaher of Howden Group Canada. A variety of bags were installed in the baghouse during the week of January 7, 1991. The bags were installed by Mr. Theron Grubb of Grubb Filtration Testing Services and Mr. Michael Kelaher of Howden. The types of bags installed and the number of each bag type include: Huyglas 1701 (40), Tefaire (2), P-84 (2), Ryton/Rastex (2), and Mikro-Tex 771 (2). Ten of the Huylas bags were installed on cages that had been fitted with DuPont Filter Guard "socks."

A sorbent injection system was installed by FP&L to be used for injecting magnesium oxide (MagOx). The MagOx was to be used as a precoat material prior to startup and was also to be injected during operation for brief intervals to provide protection to the bags during operation when PJFF outlet flue gas temperatures fell below a value 40 degrees above the acid dewpoint (expected to be about 280 °F). The PJFF was precoated with MagOx on February 27, 1991. Precoating took place with ambient air. The flow rate through the baghouse was approximately 6000 acfm (air-to-cloth ratio (A/C) = 5 ft/min). Prior to precoating the pressure drop across the clean bags was 0.4 in. $H_2O$. Sufficient MagOx was injected (at a rate of about 1.4 pounds per minute) to raise the pressure drop to 2 in. $H_2O$. The pulse cleaning system was then operated (10 pulses) to lower the pressure drop to 1 in. $H_2O$. Precoating continued until the pressure drop again increased to 2 in. $H_2O$. A second cleaning sequence was started (10 pulses) until the pressure drop was reduced to 1 in. $H_2O$. The precoating concluded after the pressure drop again rose to 2 in. $H_2O$. When the flow rate was reduced to approximately 5000 acfm (A/C = 4.2 ft/min), the pressure drop was reduced to 1.5 in. $H_2O$. The PJFF fan was then shut down.

The PJFF began filtering flue gas at 1:00 p.m. on March 4, 1991. The baghouse fan had been started an hour earlier on ambient air. The flowrate controller was set to a value of 5000 acfm. (This value would later have to be adjusted after actual flow measurements in the PJFF outlet duct.) When the baghouse was placed in service on ambient air the pressure drop was 1.5 in. $H_2O$, the same as after the last precoating on February 27th. Additional precoat material was injected to raise the pressure drop to 2 in. $H_2O$. The baghouse then began to filter hot flue gas. The PJFF was set to clean at a pressure drop of 5 in. $H_2O$. Pulsing would continue until the pressure drop was reduced to 3 in. $H_2O$. The pulse pressure was measured to be about 12 psi. After one hour of filtering flue gas, the PJFF inlet temperature was 317 °F and the outlet temperature was 245 °F (the air preheater outlet temperature was 371 °F). At 2:00 p.m. the automatic precoat system was turned on. MagOx would be injected for 2 minutes every hour when the baghouse outlet temperature was below 320 °F (40 °F above the estimated acid dew point temperature). Because the precoat system was left in automatic mode, there was inleakage of ambient air into the ductwork through the fan housing. This reduced the pulse-jet inlet temperature significantly. Later an automatic valve was installed downstream of the precoat system blower. This eliminated the inleakage, and baghouse inlet and outlet temperatures settled into an acceptable range. Generally with an air preheater outlet temperature of 390 °F (full load conditions), the pulse-jet inlet temperature averaged about 350 °F and the outlet temperature averaged about 310 °F. On the evening of March 4, 1991 it was decided to use precoat for 2 minutes every hour with a boiler gross megawatt output above 300 and two minutes every 30 minutes for operation below 300 MW. The following evening (March 5, 1991) it was decided to use precoat in the future only during operation below 300 MW and only for 2 minutes every hour. This practice continued until March 13, 1991.

On March 5, 1991 the volumetric flow rate was measured (pitot traverse) to be about 6000 acfm (A/C = 5 ft/min). The flow controller was adjusted to control to a value of about 4800 acfm (A/C = 4 ft/min). Subsequently difficulty developed in controlling flow because the flow measurement system became contaminated with ash blown from the hopper back into the outlet duct where the flow measuring annubar (pitot) was installed. A compressed air system had to be installed to purge the pitot system occasionally. By March 13, 1991 when the volumetric flow rate was again measured, the flow rate had increased to about 6000 acfm (A/C = 5 ft/min) again.

Until noon on March 8, 1991 the pulse-jet baghouse was cleaning about every 45 minutes to an hour and three or four pulses were required to reduce the pressure drop from five to three inches $H_2O$. By March 13, 1991 the number of pulses required to clean the baghouse down from 5 to 3 in. $H_2O$ had increased to 10 to 12. The time between cleanings was still approximately 45 to 60 minutes. Because of a problem with the host boiler the pulse-jet baghouse was shut down at 4:00 p.m. on March 13, 1991. After cleaning the pulse jet for five minutes, the precoat system was turned on and sufficient MagOx was injected using ambient air to raise the pressure drop to 2 in. $H_2O$. The pressure drop after cleaning had been 1.5 in. $H_2O$. The host boiler was to be off line for approximately one week. The pulse-jet baghouse had accumulated 219 hours of operation.

On March 14, 1991 the pulse-jet baghouse was inspected. The top access doors were removed to inspect the tubesheet. The top plenum was very clean. There were no obvious leaks from any of the bags. Several of the bags were felt by reaching down into the bag cage. The Huyglas bags felt somewhat stiff and boardy, not very pliable. On the other hand, the P-84, Ryton, and Tefaire bags were more supple. The DuPont Filter Guard "socks" were in good shape, appearing to be snug on the cages. Each of the bags had a slight greenish tinge to its inside surface, indicating the working of the orimulsion ash through the bag fabric at the top of the bag. There was no indication of moisture condensation problems on the walls or tubesheet. Later a window hatch on the side of the baghouse was opened for viewing the bags. There was a fair amount of ash still residing on several bags; however, some of the Huyglas bags appeared to have been pulsed recently. There was a light coating of MagOx on each of the bags remaining from the final precoating after shutdown. The Huyglas bags felt stiffer than the other bags that could be handled from the small window.

The ash hopper "poke hole" was opened for inspection. Unfortunately, it appeared that ash was residing inside the hopper above the "poke hole" level. There was some concern that the rotary feeder and blower system were not adequately disposing of the ash. (If there was a significant amount of ash residing in the hopper, this could explain the increased number of pulses required for bag cleaning prior to shutdown. The ash could be reentraining onto the bags.) A decision was made to open up the ash line under the hopper and determine whether there was any blockage. The ash hopper was to be vacuumed out first. The rotary feeder will also be checked for proper operation. (On March 18, 1991 Mr. Renn Larson (FP&L) reported that, although a two-inch vacuum line operated for six hours on March 15, 1991 in an attempt to empty the hopper, the hopper was not empty by the end of the day.)

In summary, the PJFF operated for slightly over 200 hours filtering orimulsion ash at an air-to-cloth ratio ranging from 4 to 5 ft/min. The cleaning set points were 5 to 3 in. $H_2O$. Cleaning was occurring every 45 to 60 minutes. For the first 100 hours of operation 3 or 4 pulses were required to reduce the pressure drop. By the end of the operating period 10 to 12 pulses were required to complete the cleaning sequence, probably due to ash reentrainment from the hopper. Compartment inlet and outlet temperatures averaged 350-360 °F and 310-320 °F, respectively.

Ecolaire Reverse-Gas Pilot Baghouse (RGFF)

The Ecolaire reverse-gas cleaned pilot baghouse was installed by Mr. Lou Rettenmaier, PPM Construction Company, and FP&L. Bags were provided by Elkem Technology, Inc. and W.L. Gore and Associates, Inc.. Twenty Gore-Tex membrane bags were installed in each of the four compartments. The bags were installed by Mr. Frank Maresca and Mr. Frank Lawrence of Gore. Since each compartment can accommodate 36 bags, thimble caps were installed on the 16 unused thimbles. After bag installation, the baghouse was "blacklighted" using a fluorescent powder to locate leaks. Most of the leaks were around the thimble caps. Silicone sealant was used to correct the leaking caps. A second "blacklighting" was performed using a different colored powder. All previous leaks had been sealed properly.

The Ecolaire reverse-gas cleaned pilot baghouse was placed in service on March 6, 1991. At 9:00 a.m. precoating with MagOx began. The MagOx was injected at a rate of about 1.4 pounds per minute. Precoating occurred using ambient air. Just prior to precoating the flange-to-flange pressure drop (FFdP) was 2.6 in. $H_2O$. The four compartment tubesheet pressure drops were 0.2, 0.2, 0.4, and 0.6 in. $H_2O$ for compartments 1 through 4, respectively. After one hour of precoating and just before flue gas was filtered, the FFdP was 3.6 in. $H_2O$ and the compartment tubesheet pressure drops were 0.6, 0.8, 1.0, and 1.3 in. $H_2O$ for compartments 1 through 4, respectively. Flue gas was first filtered at about 10:00 a.m.. The attached tables, prepared by Mr. Thorstein Lindeberg of Elkem Technology, show the pressure drop behavior of the

RGFF for the first several days of operation. On the morning of March 8, 1991 a measurement of the volumetric flowrate in the RGFF outlet duct was conducted. The value was about 17,000 acfm. This relates to an air-to-cloth ratio of about 4.5 ft/min. During the first days of operation it was observed that baghouse pressure drop was affected significantly by reverse gas fan operation (on/off) and by operation of the Aquatech/Soxal system downstream from the RGFF.

The baghouse has been cleaned at a flange-to-flange pressure drop of about 8 in. $H_2O$. The baghouse was initially cleaned in a batch-clean mode with each compartment being cleaned once. With a single cleaning of each compartment, the FFdP after cleaning was about 6 in. $H_2O$. These values were with the reverse gas fan in operation. The reverse gas fan was operated with the damper in its full-open position. The recirculating reverse gas volumetric flowrate was measured to be about 7000 acfm. (It is very difficult to determine the true flow during the actual reverse gas period.) The precoating system was operated only during the period of cleaning of the bags. Since all of the first cleaning sequences were initiated manually, this operation was easily accomplished. On March 9, 1991 the baghouse microprocessor program was altered to allow the baghouse to be placed in an automatic, timed-cleaning mode with 15 minutes between the cleaning of consecutive compartments. The baghouse was operated in this fashion until the baghouse was taken out of service on the morning of March 12, 1991. The precoat system was not in operation during this time.

After the RGFF was placed in service, it was determined that the reverse gas fan was vibrating badly. The reverse gas fan was operated only during cleaning periods until the morning of March 9, 1991 when the cleaning parameters were changed. It was then run continuously. By March 12, 1991 the vibrations had become so bad that the RGFF was shutdown until the fan bearings could be replaced. An inspection of the compartments after shutdown revealed that in general the bags were in very good shape. There was only one thimble cap that had come off in compartment 4. This explains the low tubesheet pressure drop values in this compartment after 2:30 a.m. on March 6, 1991 (see attached tables). There were drip marks on some of the thimble caps. It was determined that this was due to condensation on the cold metal of the sonic horn housing at the top of each compartment. The external portion of each horn will be insulated prior to restart.

The ash hopper evacuation system did not operate well at first. There was quite a bit of old ash from previous operation of the system that had to be cleaned out after the "poke holes" were opened up. There was some difficulty in working the old, hardened, pieces of Powder River Basin fly ash through the ash removal system. Vibrators were installed on each hopper to help work the ash down into the rotary feeder. One old bag clamp jammed the rotary feeder on compartment 1 immediately after startup. This system should be in good working order by the time the RGFF is operating again. After startup it was determined that there were a number of leaks in the baghouse structure that resulted in low outlet gas temperatures (see the attached table). During the current outage these leaks will be sealed. During full load operation, the outlet had been consistently 100 °F cooler than the inlet.

Baghouse Computerized Monitoring System

This system has worked fairly well during the early operation of the baghouses. The main problems have been the lack of good correlations between pressure transducer outputs and actual pressure drop values and an apparent problem with the computer that prevented data collection between March 7 and March 13, 1991.

These problems have been resolved and the system should be operating properly upon system restart. At the current time the following parameters are being logged into the system:

Howden Pulse-Jet Pilot Baghouse

Air Preheater Temperature
PJFF Inlet Temperature
PJFF Outlet Temperature
PJFF Tubesheet Pressure Drop
PJFF Volumetric Flowrate
Pulse Manifold Pressure
Number of Pulses
Number of Cleans
Precoat System On/Off

Ecolaire Reverse-Gas Pilot Baghouse

Air Preheater Temperature
RGFF Inlet Temperature
RGFF Outlet Temperature
RGFF Volumetric Flowrate
RGFF Flange-to-Flange dP
Compartment 1 Tubesheet dP
Compartment 2 Tubesheet dP
Compartment 3 Tubesheet dP
Compartment 4 Tubesheet dP
RGFF Reverse Gas Volumeteric Flowrate
Precoat System On/Off

If you have any questions about this report, please contact me at your convenience.

Yours truly,

Kenneth M. Cushing, Head
Fabric Filter Research Section

SRI-91-259-7218
Attachment

KMN/lcr

cc: Dr. K.R. Olen (FP&L)
Mr. Frank Fereday (Elkem)
Mr. Thorstein Lindeberg (Elkem)
Mr. Frank Maresca (Gore)

SANFORD ORIMULSION PROJECT

ECOLAIRE REVERSE GAS PILOT BAGHOUSE PERFORMANCE DATA

| Date/Time | FFdP in. $H_2O$ | TS1dP in. $H_2O$ | TS2dP in. $H_2O$ | TS3dP in. $H_2O$ | TS4dP in. $H_2O$ | Temp (In) °F | Temp (Out) °F | Comments |
|---|---|---|---|---|---|---|---|---|
| 3/6/91 | | | | | | | | |
| 8:45 a.m. | 2.6 | 0.2 | 0.2 | 0.4 | 0.6 | | | Start MgO inj. @ 9:00 |
| 9:50 a.m. | 3.2 | 0.6 | 0.8 | 0.9 | 1.2 | | | Start flue gas @ 10:00 |
| 10:40 a.m. | 5.4 | 1.5 | 1.7 | 2.1 | 2.4 | | | |
| 12:15 p.m. | 7.9 | 3.0 | 3.2 | 3.3 | 3.7 | 383 | 253 | With reverse gas fan on |
| 1:00 p.m. | 8.3 | 3.6 | 3.6 | 3.8 | 4.0 | 385 | 265 | |
| 2:00 p.m. | 8.2 | 4.0 | 4.1 | 4.3 | 4.4 | 382 | 272 | |
| | | | | | | | | Clean @ 2:35 p.m., inj. MgO |
| 2:40 p.m. | 4.7 | 0.7 | 0.6 | 0.7 | 0.7 | 376 | 273 | |
| 3:00 p.m. | 3.4 | 0.7 | 0.7 | 0.8 | 0.9 | 379 | 275 | Reverse gas fan off |
| 4:00 p.m. | 6.3 | 1.3 | 1.1 | 1.2 | 1.0 | 388 | 285 | |
| 5:00 p.m. | 6.0 | 1.5 | 1.5 | 1.5 | 1.3 | | | |
| 8:10 p.m. | 5.8 | 2.5 | 2.4 | 2.6 | 2.0 | 382 | 286 | |
| | | | | | | | | Clean @ 8:30 p.m., inj. MgO |
| 9:00 p.m. | 5.6 | 0.9 | 0.8 | 0.8 | 0.7 | 377 | 284 | |
| 3/7/91 | | | | | | | | |
| 3:45 a.m. | 7.3 | 3.1 | 2.9 | 2.9 | 2.3 | | | |
| | | | | | | | | Clean @ 3:50 a.m., inj. MgO |
| 4:00 a.m. | 5.1 | 0.6 | 0.6 | 0.7 | 0.6 | 306 | 255 | |
| 8:10 a.m. | 7.4 | 2.8 | 2.8 | 3.0 | 2.4 | 383 | 289 | |
| 9:00 a.m. | 8.5 | 3.2 | 3.2 | 3.3 | 2.6 | 384 | 293 | |
| | | | | | | | | Clean @ 9:25 a.m. |
| 10:10 a.m. | 6.5 | 1.3 | 1.1 | 1.3 | 1.3 | | | |
| 11:00 a.m. | 6.6 | 1.6 | 1.5 | 1.6 | 1.4 | | | |
| 1:00 p.m. | 7.2 | 2.6 | 2.7 | 2.8 | 2.3 | | | |
| | | | | | | | | Reverse gas fan off @ 1:30 |
| 2:00 p.m. | 5.5 | 2.9 | 3.1 | 3.5 | 3.0 | | | |
| 3:05 p.m. | 6.1 | 3.3 | 3.5 | 3.8 | 3.2 | | | |
| | | | | | | | | Clean @ 3:35 p.m. |
| 5:00 p.m. | 3.4 | 1.7 | 1.5 | 1.3 | 1.6 | | | |
| 11:00 p.m. | 3.3 | 2.2 | 2.2 | 2.3 | 2.0 | 371 | 259 | |
| | | | | | | | | Clean @ 11:45 p.m. |
| 12:00 p.m. | 1.6 | 0.7 | 0.6 | 0.6 | 0.8 | 370 | 261 | |
| 3/8/91 | | | | | | | | |
| 8:45 a.m. | 8.1 | 5.4 | 5.5 | 6.0 | 5.2 | | | Static pres. clean side (-27 in. $H_2O$) Clean @ 9:00 a.m. |
| 12:10 p.m. | 8.4 | 4.3 | 4.4 | 5.4 | 4.5 | | | |
| | | | | | | | | Clean @ 12:20 p.m. twice |

## SANFORD ORIMULSTION PROJECT - ECOLAIRE PERFORMANCE DATA

### PRESSURE DROP DATA - BEFORE, DURING, AND AFTER CLEANING EACH COMPARTMENT

| Date/Time | FFdP in. $H_2O$ | | TS1dP in. $H_2O$ | | | TS2dP in. $H_2O$ | | | TS3dP in. $H_2O$ | | | TS4dP in. $H_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B | A | B | D | A | B | D | A | B | D | A | B | D | A |
| 3/6/91 | | | | | | | | | | | | | | |
| 2:25p.m. | | | 4.3 | -0.7 | 0.9 | 2.9 | -0.9 | 0.6 | 2.1 | -1.0 | 0.6 | 1.4 | -1.0 | 0.6 |
| 8:30p.m. | 7.2 | 5.4 | 2.7 | -1.0 | 0.8 | 2.0 | -1.1 | 0.6 | 1.7 | -1.1 | 0.6 | 1.1 | -1.0 | 0.6 |
| 3/7/91 | | | | | | | | | | | | | | |
| 3:50a.m. | 7.3 | 5.1 | 3.1 | -1.0 | 0.8 | 2.2 | -1.0 | 0.6 | 1.8 | -1.0 | 0.6 | 1.1 | -1.1 | 0.6 |
| 9:25a.m. | 8.8 | 6.2 | 3.3 | -1.1 | 0.9 | 2.4 | -1.1 | 0.6 | 2.0 | -1.1 | 0.5 | 1.4 | -1.1 | 0.7 |
| 3:35p.m. | 8.6 | 6.3 | 3.6 | -1.3 | 1.9 | 3.0 | -1.1 | 1.1 | 2.5 | -1.2 | 0.6 | 1.4 | -1.4 | 0.9 |
| 11:45p.m. | 4.7 | 3.3 | 2.3 | -1.7 | 1.3 | 1.8 | -1.5 | 0.7 | 1.3 | -1.7 | 0.5 | 0.8 | -1.8 | 0.6 |
| 3/8/91 | | | | | | | | | | | | | | |
| 9:00a.m. | 11.2 | 6.3 | 6.2 | -1.2 | 2.0 | 4.4 | -1.2 | 1.2 | 3.5 | -1.9 | 1.8 | 2.5 | -1.8 | 1.5 |
| 12:20p.m. | 9.8 | 5.6 | 5.1 | -1.6 | 2.7 | 3.9 | -1.5 | 2.8 | 4.2 | -1.3 | 2.5 | 3.0 | -1.3 | 2.6 |
| 12:30p.m. | 5.6 | 4.3 | 0.0 | -1.5 | 2.4 | 2.8 | -1.5 | 2.6 | 3.0 | -1.3 | 2.7 | 2.9 | -1.2 | 2.7 |

B - Before Cleaning
A - After Cleaning
D - During Reverse Gas Flow

PROGRESS REPORT NO. 2 APRIL 19, 1991

# ORIMULSION TEST BURN DEMONSTRATION PROJECT - FPL SANFORD UNIT 4 POWER PLANT

## TRANSPORTABLE PULSE-JET PILOT PLANT
## ECOLAIRE REVERSE-GAS PILOT PLANT

SRI Project Manager: K. M. Cushing
EPRI Project Mamager: R. Chang

## PROJECT SUMMARY

Florida Power & Light Company (FPL) and the Electric Power Research Institute (EPRI) are supporting a demonstration of pulse-jet and reverse-gas fabric filter technology for particulate control from a boiler fired with Orimulsion, an emulsion of a naturally occurring bitumen in water. The demonstration project is located at the 400-MW Sanford Unit 4 in Sanford, Florida.

Tests are conducted using two pilot-scale fabric filters. The pulse-jet fabric filter is one of the EPRI Transportable Pulse-Jet (TPJ) fabric filter pilot units. This TPJ is of similar geometry to one module of a full-scale, low pressure high volume pulse-jet fabric filter. The reverse-gas fabric filter is the four-compartment Ecolaire fabric filter pilot plant originally installed at EPRI's Arapahoe Test Facility in Denver, Colorado.

During this reporting period, March 13 through April 16, 1991, the TPJ and Ecolaire pilot baghouses accumulated approximately 450 and 300 hours of operation, respectively. The pilot baghouses had been taken out of service on March 13, 1991 because of an outage at the host boiler. The plant remained off line until March 25, 1991. Both pilot plants were placed in service on the afternoon of March 25 and, except for off-line periods to be explained below, it remained in service until April 12, 1991, the beginning of a five-day outage at the host boiler.

## ACCOMPLISHMENTS IN THE CURRENT REPORTING PERIOD

## PULSE-JET PILOT PLANT OPERATION

As mentioned in the previous progress report, it had been determined that the pulse-jet baghouse ash removal system had not been working properly between startup on March 4 and the outage that began on March 13. During the outage beginning on March 13, the TPJ hopper was emptied of the accumulated ash. The rotary feeder and ash disposal duct that connects to the outlet duct also had to be removed and cleaned. Upon restart on March 25 a restriction was placed in the outlet duct (partially closing the guillotine shutoff damper). This altered the pressure balance within the system sufficiently to allow the ash blower to properly extract flue gas from the inlet duct, blow it pass the outlet of the hopper's rotary feeder, and return the flue gas into the outlet duct.

On April 2, 1991 the TPJ tripped off line due to what was thought by FPL personnel to be a high opacity alarm (although it was thought by SRI personnel that this equipment was not in service). The TPJ was placed back in service on April 3, 1991. The TPJ was not inspected for failed bags. After an analysis of the data, it is suspected that the baghouse shutdown was due to a high pressure drop alarm. This high pressure drop alarm probably occurred because the TPJ cleaning initiate setpoint had been set artificially high on April 2 so that TPJ cleaning would not occur during compliance tests taking place on the Unit 4 stack.

During the April 12-16, 1991 outage the TPJ was inspected. It was found that the two bags made from P-84 fabric had failed. An analysis of the data indicates that the failures probably occurred on April 7, 1991. An inspection of the tubesheet revealed that only the Huyglas cuff remained at the top of the bag. The P-84 bag remnants were found in the hopper. The bags appeared to have split vertically along the narrow side of the oval. It was also observed that the hopper was about half filled with ash. Apparently the ash had bridged over and was not feeding properly into the rotary feeder. The hopper was vacuumed out. The failed bags will be shipped to Grubb Filtration Testing Services for inspection and failure analysis. Because of the failed bags the tubesheet had become dirty. The accumulated ash and precoat material was swept into the tubesheet holes where the failed bags and cages had resided. New Huyglas bags and the original cages were installed in place of the failed P-84 bags. An inspection of the other bags did not reveal any other failed bags.

## REVERSE-GAS PILOT PLANT OPERATION

The Ecolaire reverse-gas pilot plant was placed back in service on March 25, 1991. The pilot unit continued to experience high negative static pressure within the baghouse, high flange-to-flange pressure drop, high tubesheet pressure drop, low reverse gas volumetric flowrate during cleaning, poor bag cleaning, and erratic filtering flow rate due to fluctuations in the operation of the AquaTech FGD system downstream from the baghouse. Because of concern about the high negative static pressure within the baghouse (-25 to -30 in. $H_2O$), a decision was made to reroute the flue gas flow so that the induced draft fan became a forced draft fan. This activity took place between March 28 and April 3, 1991. When the baghouse was again placed in service the static pressure within the baghouse was essentially zero.

Baghouse operation continued to be erratic even after fan relocation. Baghouse flowrate could not be stabilized at a particular value for long periods of time and bag cleaning continued to be poor. It was determined that the flange-to-flange pressure drop was artificially high because of the placement of the pressure tap in the outlet duct. This placement is very near the location where the reverse gas recirculation duct mates with the outlet duct. It was found that accurate flange-to-flange pressure drops could be measured by closing the reverse gas recirculation poppet (effectively deadheading the reverse gas fan).

Mr. Frank Fereday of Elkem Technology visited the plant site during the week of April 8, 1991 to review operation of the Ecolaire unit with Mr. Thorstein Lindeberg of Elkem and Dr. Ken Olen of FPL. It was decided to wait until after completion of on-site activities by AquaTech to resume an attempt at stable operation of the Ecolaire pilot baghouse. This will most likely occur during the week of April 22, 1991.

## PILOT PLANT OPERATING DATA

TPJ operating data for the first 630 hours of operation are presented in figures 1, 2, and 3. Figure 1 presents the tubesheet pressure drop behavior (to make the graph more legible, a point is graphed for each ten minutes of operation). Since startup the pilot unit had operated with pressure drop initiate and terminate set points of 5 and 3 in. $H_2O$, respectively. This is reflected in the graph. The lack of data during the operating period from

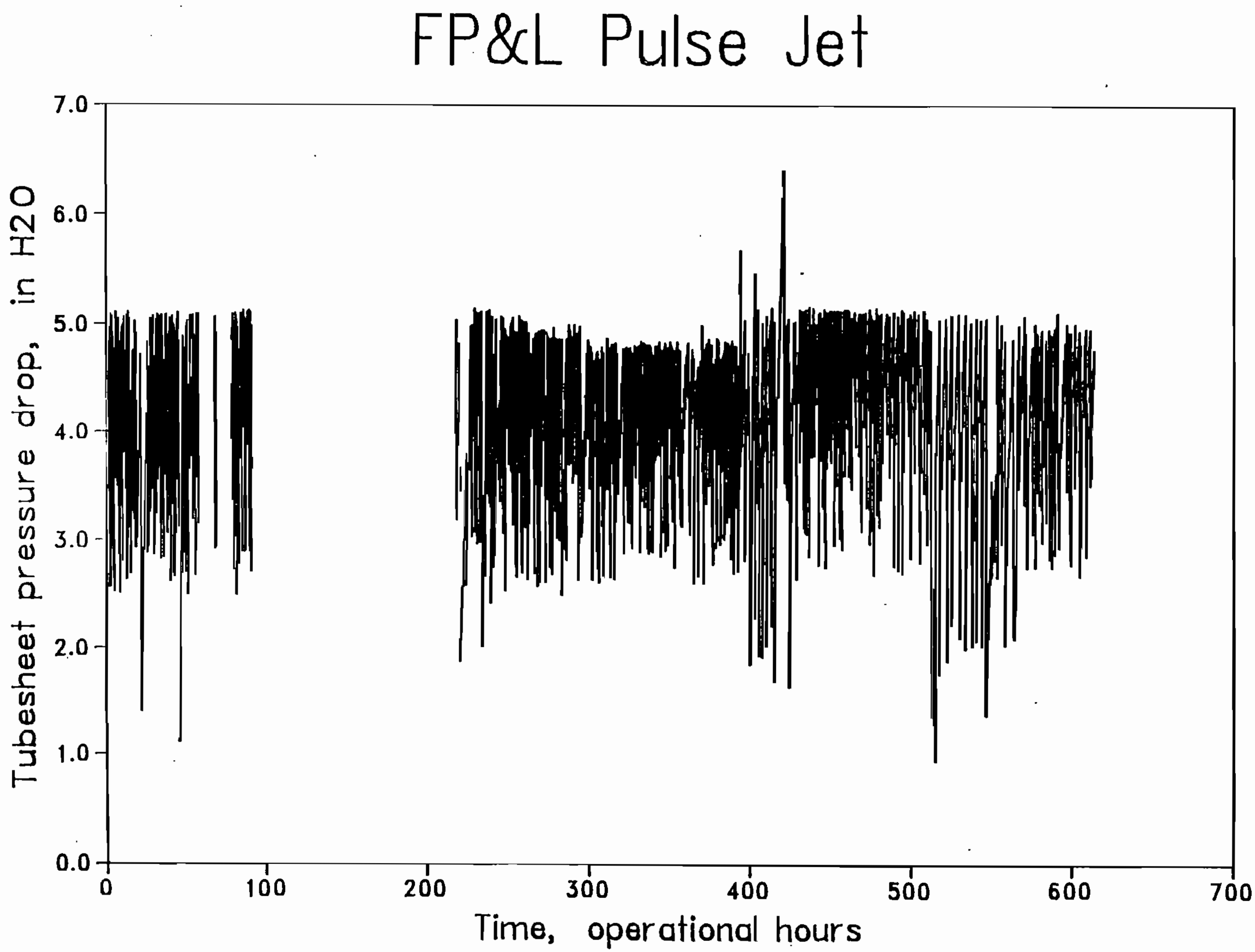



Figure 1. Tubesheet pressure drop history for the TPJ pilot baghouse during the FPL Orimulsion Test Burn Project (March 4 through April 12, 1991).

100 to 200 hours was due to the datalogging computer not being in service. The higher pressure drop values at about 400 hours refer to March 29 and April 2, 1991 when the cleaning initiate setpoint was artificially high to accommodate the compliance tests at the stack.

Figure 2 shows the behavior of the volumetric flow rate through the baghouse. The flow rate was controlled to approximately 4800 acfm (air-to-cloth ratio of 4 ft/min) for full-load conditions. Due to changes in flue gas temperature and the static pressure in the main Unit 4 duct where the TPJ inlet and outlet ducts tie in, the flowrate decreases during periods of low load operation.

Figure 3 shows the behavior of the TPJ inlet temperature during the first 630 hours of operation. The inlet temperature generally varies between 400 F and 300 F depending on the boiler load. The diurnal variation of load can easily be seen in this figure.

Until March 29, 1991 problems with interfacing the computer datalogger and the TPJ control cabinet prevented the accumulation of data concerning the number of cleaning events per day and the number of pulses per cleaning. (Data on the number of pulses per cleaning is still not being logged on the computer.) Figure 4 shows the number of cleanings per day beginning with March 29, 1991. The number of cleaning events for April 2 and 3 are suspect due to the lack of information related to the exact time when the TPJ tripped off line and when the unit was placed back in service. The lower number of cleaning events per day after April 6, 1991 indicates that this may be the time period (4/7/91) when the P-84 bags failed. The small number of cleanings on April 12, 1991 reflect the fact that the TPJ was taken out of service during the day.

Because of the erratic operating behavior of the Ecolaire reverse-gas pilot plant, graphical presentations of operating data similar to that for the TPJ were not prepared for this reporting period.

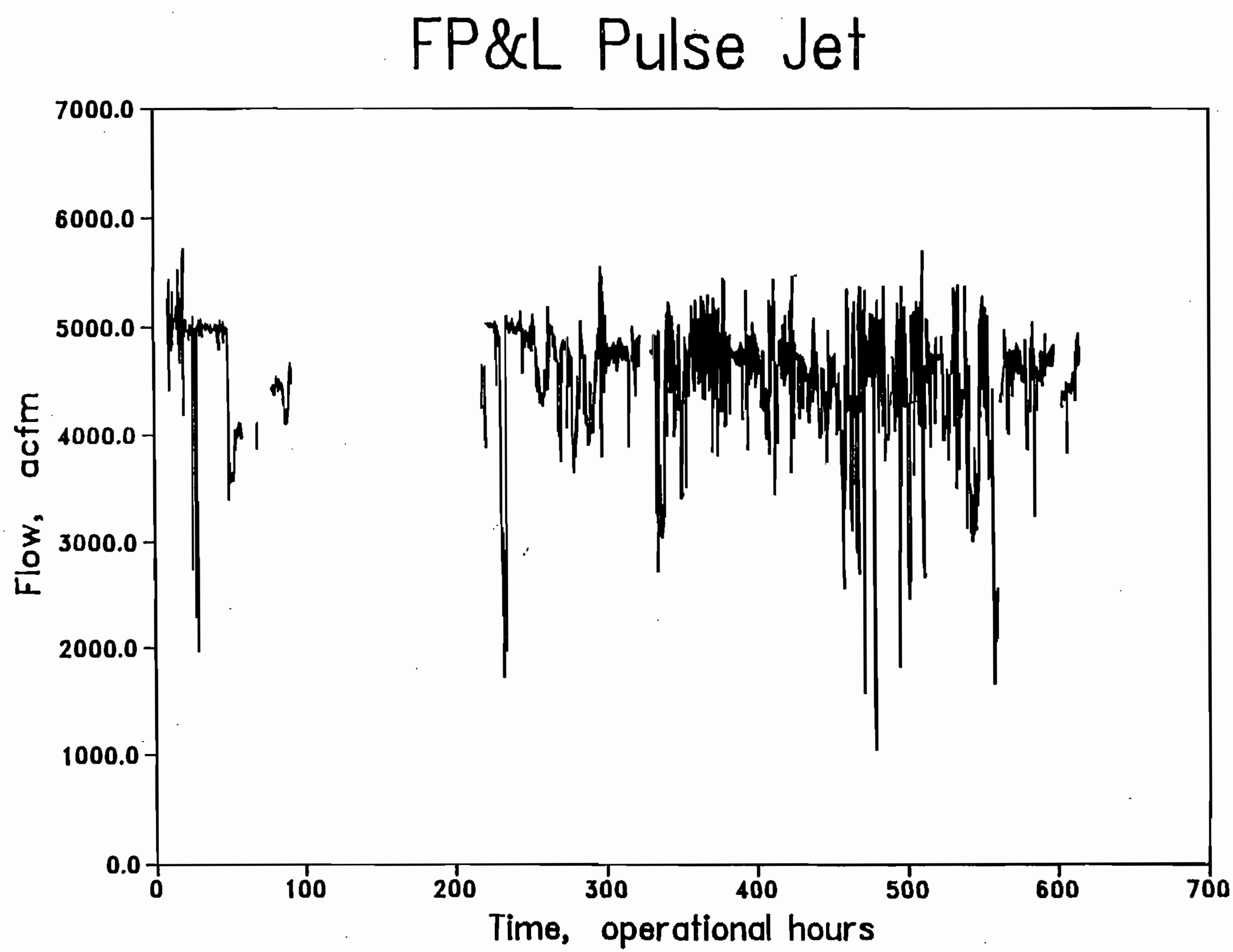



Figure 2. Volumetric flowrate history for the TPJ pilot baghouse during the FPL Orimulsion Test Burn Project (March 4 through April 12, 1991).

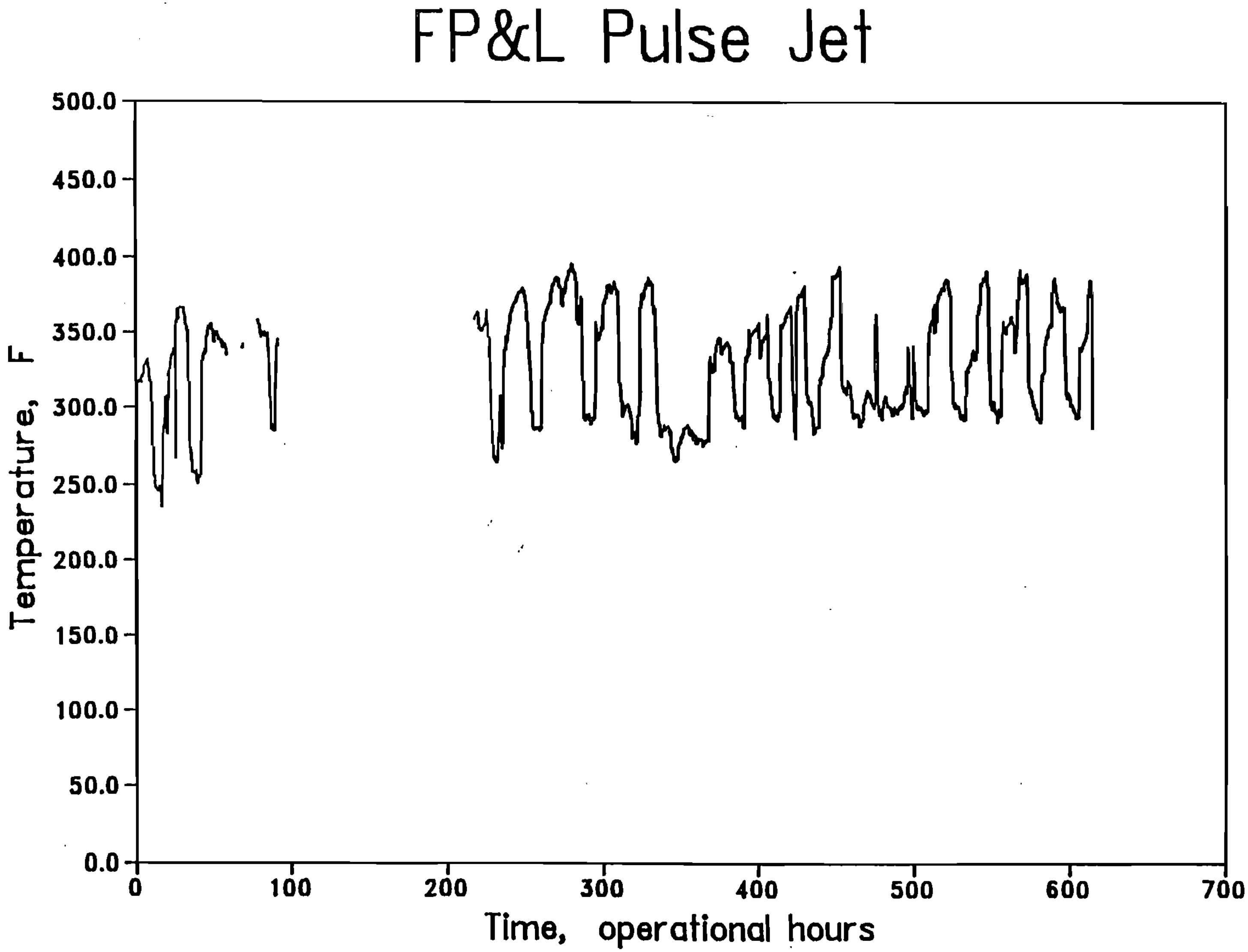



Figure 3. Inlet flue gas temperature history for the TPJ pilot baghouse during the FPL Orimulsion Test Burn Project (March 4 through April 12, 1991).

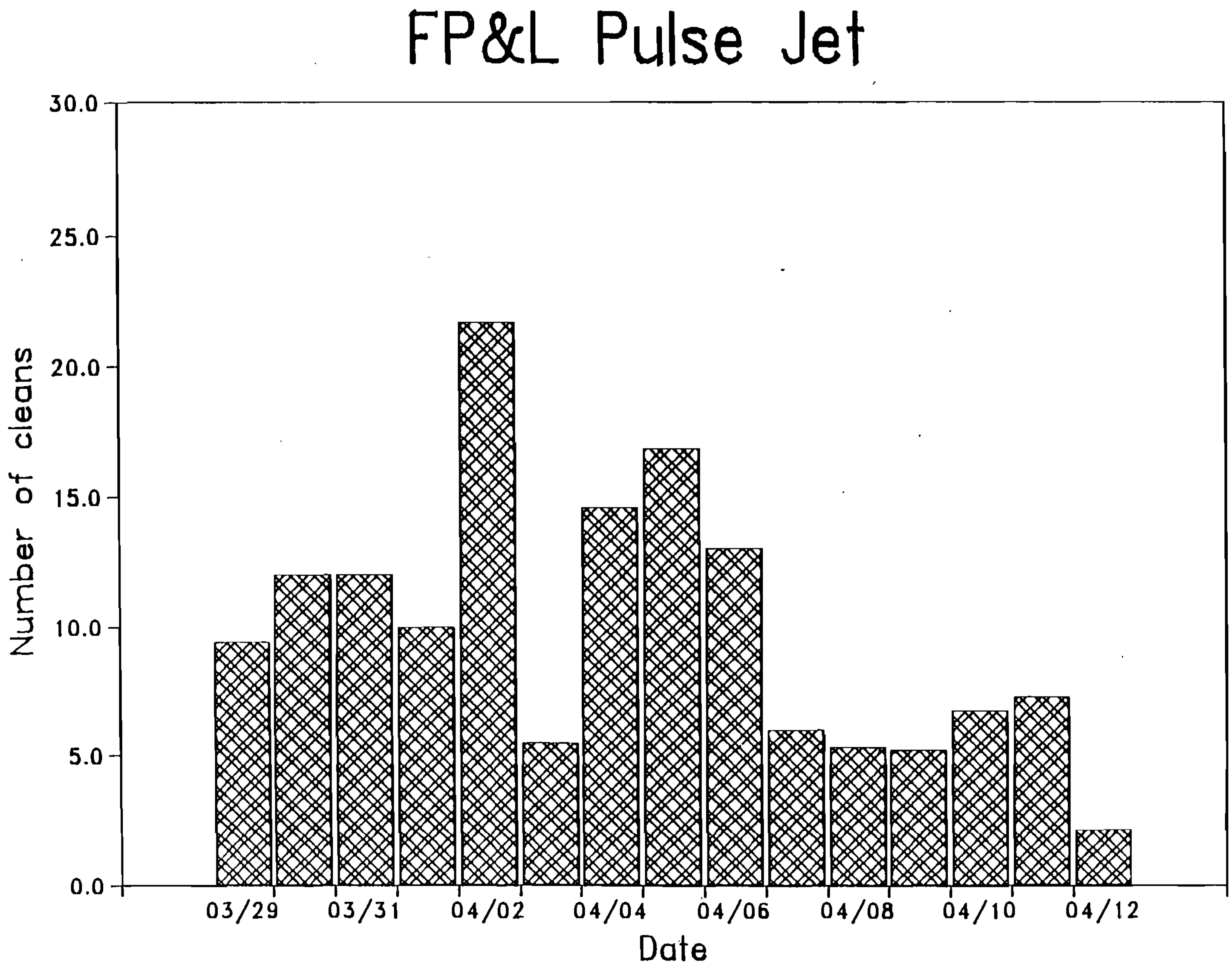



Figure 4. Number of cleaning events per day for the TPJ pilot baghouse during the FPL Orimulsion Test Burn Project (March 29 through April 12, 1991).

**Southern Research Institute**

PROGRESS REPORT NO. 3 JULY 31, 1991

# ORIMULSION TEST BURN DEMONSTRATION PROJECT - FPL SANFORD UNIT 4 POWER PLANT

## TRANSPORTABLE PULSE-JET PILOT PLANT
## ECOLIARE REVERSE-GAS PILOT PLANT

SRI Project Manager: K.M. Cushing
EPRI Project Manager: R. Chang

## PROJECT SUMMARY

Florida Power & Light Company (FPL) and the Electric Power Research Institute (EPRI) are supporting a demonstration of pulse-jet and reverse-gas fabric filter technology for particulate control from a boiler fired with Orimulsion, an emulsion of naturally occurring bitumen in water. The demonstration project is located at the 400-MW Sanford Unit 4 in Sanford, Florida.

Tests are conducted using two pilot-scale fabric filters. The pulse-jet fabric filter is one of the EPRI Transportable Pulse-Jet (TPJ) fabric filter pilot units. The TPJ is of similar geometry to one module of a full-scale, low pressure high volume pulse-jet fabric filter. The reverse-gas fabric filter is the four-compartment Ecolaire fabric filter pilot plant originally installed at EPRI's Arapahoe Test Facility in Denver, Colorado.

During this reporting period, April 17 through May 31, 1991, the TPJ and Ecolaire pilot baghouses accumulated approximately 250 and 550 hours of operation, respectively. Both pilot units had been restarted on April 17, 1991 following a five-day outage at the host boiler. On the evening of April 23, 1991 the baghouses were shut down because the host unit was to begin burning fuel oil. Operation of the pilot units resumed on May 8, 1991 when the host boiler again began burning Orimulsion. Performance of both baghouses degraded badly during the next 48 hours. A very sticky ash (probably composed of a large percentage of vanadyl sulfate) was being formed downstream of the boiler because of low load operation. (At this particular time the unit was operating with high excess air values and producing a high concentration of $SO_3$. This raised the acid dewpoint to about 285°F, near the temperature of the flue gas entering the pilot units.) Pulse-jet cleaning frequency increased dramatically. The pressure drop in the Ecolaire baghouse (cleaned on a timed basis) also increased.

There was a dramatic improvement in operation on the afternoon of May 10, 1991 when the boiler resumed high load operation. However, during the following weekend, the unit operated at the low load, and by Sunday evening, May 12, 1991, the pulse-jet baghouse was in continuous cleaning. At this point both pilot units were shut down because the host boiler began burning fuel oil. The pulse-jet baghouse was not restarted, due to bag failures (discussed below) and a plugged ash removal system. Because of problems with the host boiler (a failed transformer trip and the loss of an FD fan) the Ecolaire unit was not able to restart until May 21, 1991. The Ecolaire baghouse resumed operation on May 21, 1991 and operated through May 31, 1991, the conclusion of the test program. On May 28, 1991 the host boiler began using a mixture of Orimulsion and natural gas to fire the boiler. This also continued through May 31, 1991.

## ACCOMPLISHMENTS IN THE CURRENT REPORTING PERIOD

### PULSE-JET PILOT PLANT OPERATION

As mentioned in the last progress narrative, the two P84 test bags had been removed from the baghouse during the April 12-16, 1991 outage. Two new Huyglas bags had been installed to replace these bags. Also the hopper and associated ash removal ducting were cleaned of accumulated ash.

Because of poor performance during low load operation following restart on May 8, 1991 and the subsequent discovery of failed bags on May 15 and May 20, 1991, the pulse-jet baghouse accumulated only an additional 250 hours of operation between April 17 and May 31, 1991. On May 15, during the outage that began on the previous Sunday, Mr. Thorstein Lindeberg of Elkem Technology and Mr. Renn Larsen of FPL inspected the bags in the pulse-jet baghouse. A single Huyglas bag failure (A14) was observed. (Figure 1 shows the original TPJ bag layout and the identification of the test bags installed.) This bag was replaced with a new Huyglas bag. Also another used Huyglas bag (C8) was removed for permeability testing by Mr. Lindeberg. This testing will be discussed later. During this time the hopper and ash removal ducting were again cleaned of accumulated fly ash. The rotary feeder and associated blower system on this baghouse were not able to transport the Orimulsion ash properly at any time during the operation of the pilot baghouse.

On May 20, 1991 Mr. Ken Cushing of SRI visited the site to inspect the TPJ baghouse. To more easily determine the integrity of the remaining used bags in the pulse-jet baghouse, the unit was briefly operated on ambient air while a quantity of Visolite was feed into the inlet duct. Upon inspection of the tubesheet, quite a bit of bleedthrough of the Visolite was observed through a number of bags, especially along the upper two feet of the bags.

After the baghouse was inspected on May 20, 1991, a detailed list was created noting the observations concerning each bag. Each bag was qualitatively rated based on the amount of bleedthrough of Visolite observed. The rating was either good (no bleedthrough), marginal, or bad (excessive bleedthrough). These observations are listed in Table 1.

Based on these qualitative observations, 18% of the bags in row A, 38% of the bags in row B, and 92% of the bags in row C were still in good condition as of May 20, 1991. Bags in good condition were such that very little or no bleedthrough of Visolite was observed on the interior surfaces of the bag. Bags on the outside row were in the worst shape. Two possible causes for the greater fabric deterioration on the outside row are a higher pulse force during cleaning (not measured) and cooler operating temperatures (nearer the acid dewpoint) because of the proximity to the outside wall of the baghouse. Three of the nine bags with Filter Guard installed on the cages were considered to be in bad condition. On a percentage basis, however, the bags with Filter Guard fared better in their respective rows than the remaining bags (50% in row A, 67% in row B, and 100% in row C were in good condition). After the bag inspection, the pulse-jet baghouse inspection doors were closed, and the baghouse remained out of service for the duration of the test burn.

On June 24 and 25, 1991 Mr. Theron Grubb and Mr. Ken Cushing visited the test site to remove bags and cages from the pulse-jet baghouse. All of the bags and cages were removed in preparation for the shipment of the baghouse to the next test site, TVA's Shawnee Test Facility. Several bags were removed, carefully taken off the cage, and packaged for shipment to Grubb Filtration Testing Services (GFTS). GFTS will perform tests and analyses on these used bags. The bags included the two P84 test bags (removed on 4/15/91), the two Ryton test bags, the two Tefaire test bags, and three Huyglas bags (the one removed on 5/15/91, and two removed on 6/24/91, one with and one without a Filter Guard sock). The rest of the bags were removed from the cages and thrown away.

Table 1.

TPJ Baghouse - Bag Status - May 20, 1991

| Bag Location | Original Bag Type | Replacement Bag Type and Date | Filter Guard Installed | Status May 20, 1991 |
|---|---|---|---|---|
| A1 | Huyglas | | | Bad |
| A2 | Huyglas | | | Good |
| A3 | Huyglas | | | Bad |
| A4 | Huyglas | | | Bad |
| A5 | Huyglas | | | Bad |
| A6 | Huyglas | | | Bad |
| A7 | Huyglas | | | Bad |
| A8 | Ryton | | | Bad |
| A9 | Tefaire | | | Good |
| A10 | P84 | Huyglas(4/15/91) | | Bad |
| A11 | Huyglas | | | Bad |
| A12 | Huyglas | | | Bad |
| A13 | Huyglas | | | Bad |
| A14 | Huyglas | Huyglas (5/15/91) | | Good |
| A15 | Huyglas | | | Bad |
| A16 | Huyglas | | | Marginal |
| A17 | Huyglas | | Yes | Good |
| A18 | Huyglas | | Yes | Bad |
| A19 | Huyglas | | Yes | Bad |
| A20 | Huyglas | | Yes | Good |
| | | | | |
| B1 | Huyglas | | | Bad |
| B2 | Huyglas | | | Bad |
| B3 | Huyglas | | | Bad |
| B4 | Huyglas | | | Good |
| B5 | Huyglas | | | Good |
| B6 | Ryton | | | Bad |
| B7 | Tefaire | | | Good |
| B8 | P84 | Huyglas (4/15/91) | | Bad |
| B9 | Huyglas | | | Marginal |
| B10 | Huyglas | | | Marginal |
| B11 | Huyglas | | | Bad |
| B12 | Huyglas | | | Good |

Table 1. (continued)

TPJ Baghouse - Bag Status - May 20, 1991

| Bag Location | Original Bag Type | Replacement Bag Type and Date | Filter Guard Installed | Status May 20, 1991 |
|---|---|---|---|---|
| B13 | Huyglas | | | Bad |
| B14 | Huyglas | | Yes | Good |
| B15 | Huyglas | | Yes | Bad |
| B16 | Huyglas | | Yes | Good |
| C1 | Huyglas | | | Good |
| C2 | Huyglas | | | Good |
| C3 | Huyglas | | | Marginal |
| C4 | Huyglas | | | Good |
| C5 | Huyglas | | | Good |
| C6 | Huyglas | | | Good |
| C7 | Huyglas | Huyglas (5/15/91-Test Bag) | | Good |
| C8 | Huyglas | | | Good |
| C9 | Huyglas | | | Good |
| C10 | Huyglas | | | Good |
| C11 | Huyglas | | Yes | Good |
| C12 | Huyglas | | Yes | Good |

On July 29 the pulse-jet baghouse is to be shipped to TVA Shawnee. During his site visit at that time, Mr. Cushing will inspect the cages. Up to fourteen of the cages will be shipped to TU Big Brown Station for future use in the TPJ baghouse at that site. The rest of the cages that have not been damaged will be shipped to Shawnee.

## REVERSE-GAS PILOT PLANT OPERATION

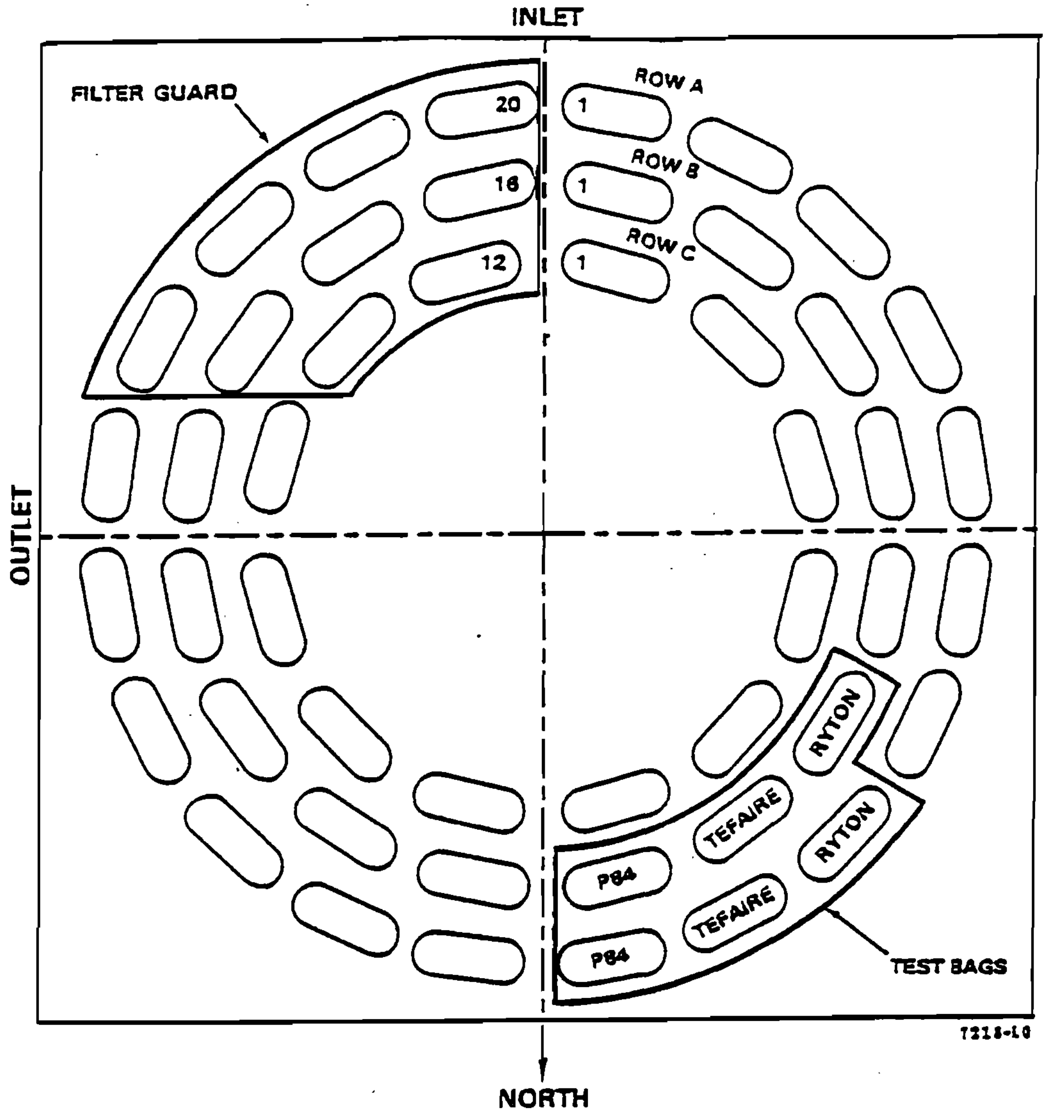
The Ecolaire reverse-gas pilot plant generally followed the same operating schedule as the TPJ, except that it also operated from May 20 through May 31, 1991. It also experienced poor performance after May 8, 1991 when filtering of the sticky, cohesive fly ash began. Performance improved after high boiler load conditions returned. Operation of the Ecolaire unit was observed first hand by Mr. Thorstein Lindeberg of Elkem Technology (Norway). He was present at Sanford during most of the test period (March 4 through May 31, 1991). Elkem is preparing a report on the operation of the Ecoliare unit. Results presented in their report will be summarized in a future progress narrative.

After the pilot baghouse was shutdown on May 31, 1991 several bags were removed for analysis. One Gore-Tex bag was removed by W.L. Gore and Associates for testing in their laboratories. On June 25, 1991 a bag was removed for testing by Grubb Filtration Testing Services.

## PILOT PLANT OPERATING DATA

Because of a failure of the Bernoulli Data Storage System used at Sanford to archive the operating data for the two pilot baghouses, there is no computer-logged data for the time period April 17 through May 20, 1991. On May 20, 1991 the data storage was switched to the hard disk in the on-site computer. Operating data for the Ecolaire baghouse for the period May 20 through May 31, 1991 have been retrieved (the TPJ was not in operation during this time) and are presented in Figure 2. The air-to-cloth ratio is shown only on a relative basis. (During the course of the testing at Sanford, no accurate relationship between the actual flow and the output of the Ecolaire flow control and measurement system was determined.) Mr. Thorstein Lindeberg of Elkem said that the average air-to-cloth ratio was approximately 2.8 ft/min during the majority of the test period. Additional clarification on the operation of the Ecolaire baghouse during the test program will be available after the receipt of the summary report from Elkem Technology.

During the week of May 13, 1991 Mr. Thorstein Lindeberg of Elkem Technology performed permeability measurements on several new and used fabric samples from the Ecoliare and pulse-jet baghouses. He used a small, hand-held, permeability tester brought with him from Norway. A small (10 cm diameter) sample of fabric is mounted in the device. Flow is measured at four pressure drop values (5, 10, 15, and 20 mm $H_2O$). The results are presented graphically in Figure 3 showing data for unused and used samples of Gore-Tex and Huyglas. The used Huyglas samples came from the two bags removed from the pulse-jet pilot unit on May 15, 1991. The used Huyglas bags demonstrated a very high loss of permeability. This is probably because of the sticky, cohesive nature of the ash that was filtered prior to the removal of the test bags. These same ash characteristics apparently did not have as great an affect on the permeability of the Gore-Tex bags. Additional permeability data should be available from Grubb Filtration Testing Services after they have completed their analysis of the used bags.




**FP&L SANFORD UNIT 4 ORIMULSION TEST BURN PROJECT**
**HOWDEN TRANSPORTABLE PULSE-JET BAGHOUSE**
**TEST BAG AND "SOCK" LOCATION**

| | | |
|---|---|---|
| <u>Bags:</u> | Ryton/Rastex | - A8, B6 |
| | Tefaire | - A9, B7 |
| | P84 | - A10, B8 |
| | Huyglas | - All Others |

<u>Socks (DuPont Filter Guard):</u>

Full-Length (tied off above top of cage) - A17, A18, A20, B14, B15, C11, C12

Short (tied to 3rd cage ring, 10" from top) - A19, B16

Figure 1. Location of the test bags and the du Pont Filter Guard "socks" in the Howden Transportable Pulse-Jet Baghouse located at the FPL Sanford Plant.

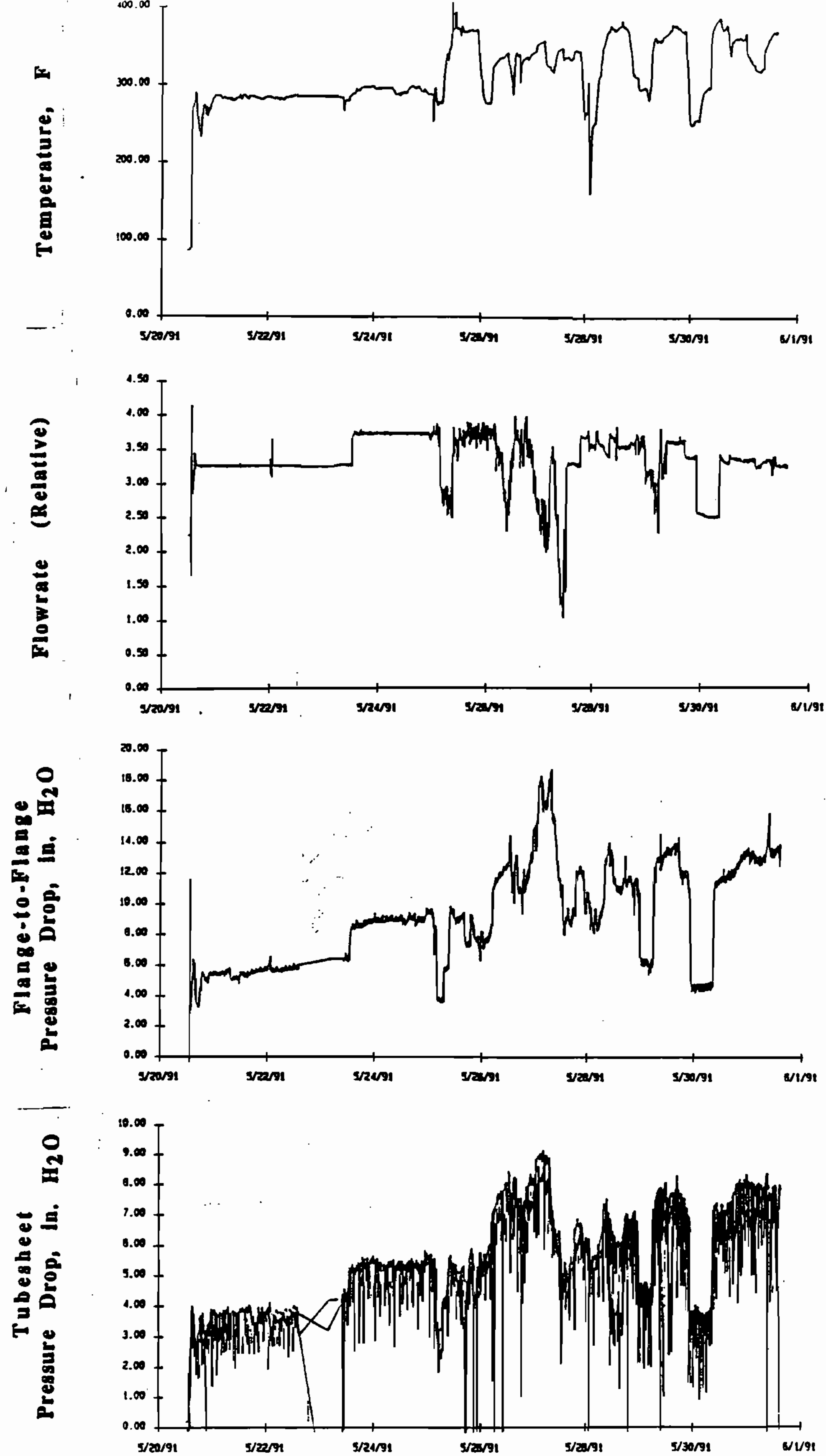



Figure 2. Operating data for the Ecolaire reverse-gas baghouse at the FPL Sanford Plant for the period May 20 through May 31, 1991.

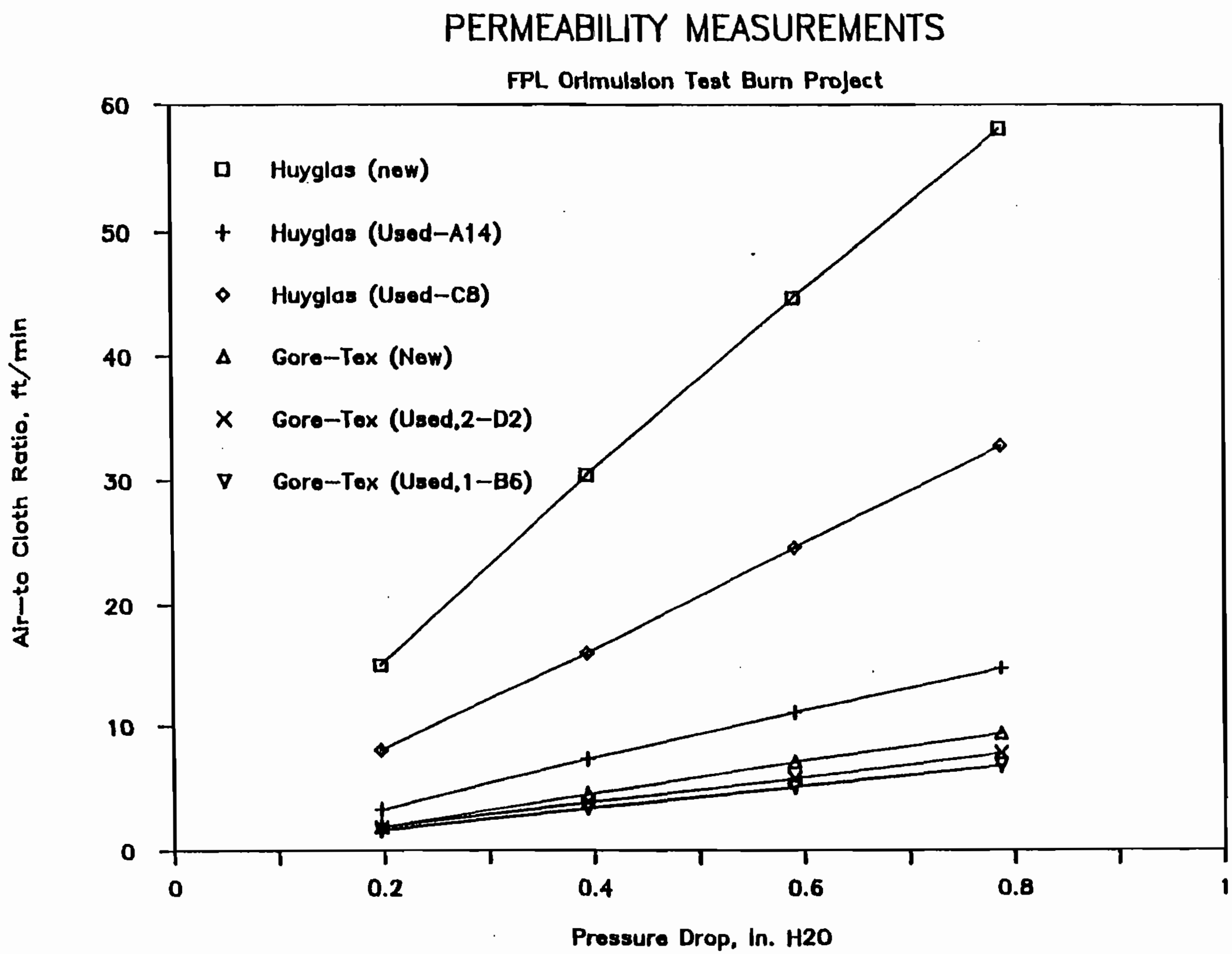



Figure 3. Fabric permeability data for new and used Gore-Tex and Huyglas samples. Data prepared by Elkem Technology.

# APPENDIX 3.6

# HOWDEN PULSE-JET FABRIC FILTER

# OPERATION MANUAL

HOWDEN ENVIRONMENTAL SYSTEMS

PULSE-JET FABRIC FILTER PILOT PLANT

Operation and Maintenance Manual

Electric Power Research Institute
Florida Power and Light Company
Orimulsion Test Burn Project
Sanford Plant, Unit 4
Sanford, Florida
December 1990

TABLE OF CONTENTS

# 1. PLANT DESCRIPTION

## 1.0 General

The supplied filter plant is a transportable demonstration model of a Howden "RF" Dust Filter with pulse jet cleaning.

Large scale versions of this equipment are typically installed on power plants to remove fly-ash from flue gases as an effective means of air pollution control.

The filter consists of a vertically mounted rectangular 3/16" steel shell measuring 5'4" square by 21' 9 3/4" long which contains the filter bags. Welded to the bottom of the filter shell is a 6'5' high, square, shaped, dust collecting hopper complete with electrical heaters and rotary dust removal valve.

The entire shell and hopper are covered with a 4" thick layer of glass wool insulation and an outlet cladding of 7/8" corregated aluminium. Mounted on top of the shell is a removable cleaning head frame assembly consisting of a platform with access covers, diaphragm valve, motor driven rotary cleaning head and air reservoir. ~~An alternate high/intermediate pressure cleaning head can be fitted~~

Parallel with the shell body are vertically mounted inlet and outlet ducts complete with control dampers and test ports.

The entire assembly is supported by a steel framework of I-beam and channel construction.

Located at the base of the framework are the inducted draft fan and cleaning air blower.

Vertical ladders and horizontal platforms are provided for access.

The plant is transportable in that, after removal of the ladder and walkways, it can be shipped as a complete package lying on its side on a low loader.

A separate trailer containing the control panel and plant monitoring equipment is also provided.

1.1 Cell Plate

A cell plate manufactured from 1/4" carbon steel plate is stiffened and welded inside of and adjacent to the top of the filter shell. This plate contains 48 oval shaped holes arranged in three concentric circles from which the filter bags are suspended. It also acts as a seal between the dirty gas and clear gas compartments.

1.2 Bags and Support Cages

Suspended from the cell plate are 48 - 20' long bags which are manufactured from Ryton/Ryton needled felt. These bags are open at the top and closed at the bottom and have a special arrangement of seam folding and stitching designed to avoid dirty gas leakage through the bags. The gas flow is from the outside to the inside of the bags with the clean gas discharging from the open tops.

The top of each bag has a reinforced cuff with two sewn-in "O" rings and a stainless steel band. The "O" rings provide support at the cell plate and prevent upward and downward movement. The stainless steel band, which is sufficiently flexible to be inserted into the cell plate hole, snaps back to form a seal against the cell plate.

Each bag is supported internally by a carbon steel, 14 AWG wire cage which prevents the bags from collapsing under gas flow pressure.

When installing the bags, the bag is inserted first into the cell plate hole with the seam of the cuff in the middle of the flat section of the hole and positioned with the "O" rings and snap cuff. The cage is then lowered into the bag and rests on its cap which covers the upper "O" ring for protection.

No tools are required to carry out installation or removal of the bags.

## 1.3 Hopper Heaters

Strip heaters are affixed directly on the hopper in order to prevent condensation which would cause the dust to solidify.

The power supply contactor for the heaters is contained within the power panel and remains on while control power is on.

Two thermostats have been provided, one to control the heating cycle and the other as a safety switch against excessive temperature.

A control switch and status lights have been provided on the control panel.

Power to the hopper heating system is not governed by the control logic and it should remain switched on at all times.

## 2. CONTROL SYSTEM DESCRIPTION

### 2.1 General

The filter comes complete with a hardwired relay control system contained in two panels; power panel (#1) and control panel (#2).

~~Incorporated into the control system is a small programmable controller used for the sequencing of the six cleaning solenoids which are employed on the alternative HP/IP cleaning head.~~

### 2.2 Controlled Elements

The elements to be controlled are:-

4 motorised dampers
1 motor driven induced draft fan
1 motor driven cleaning blowers
1 motor driven cleaning manifold
1 motor driven rotary valve airlock
1 pulse timer
1 diaphragm valve

### 2.3 Power Panel # 1

This panel contains the main supply fused disconnect switch, motor starters, motor fuses and the hopper heater contactor and is mounted at the base of the filter structure.

### 2.4 Control Transformer

Mounted adjacent to the power panel is a 15 KVA, 480/120V single phase transformer which provides power to the control panel # 2, the lighting circuit, the power receptacles and control trailer. Primary side fuses are installed in the power panel.

### 2.5 Control Panel # 2

The control panel is installed in the portable control trailer and contains all control relays, timers, control fuses as well as the programmable controller. Mounted in the door of the control panel are all control handswitches, pushbuttons, indicating lamps, flow controller temperature controllers, the cell plate differential pressure photohelic switch and a pulse counter.

Also attached to the door is a plastic mimic of the system.

## 2.6 Junction Boxes

Five junction boxes, used for marshalling the control signals to and from the field devices, are mounted on the filter structure.

The electric wiring between the field devices and the junction boxes are so arranged as to separate analog signals from digital signals.

Two of the junction boxes (JB1A & JB2A), which are mounted near the top of the filter structure, are fitted with plugs and sockets to allow quick disconnection of all electrical devices mounted on the filter top frame. ~~This is to enable the speedy interchange of the alternate filter tops.~~

One junction box (JB3) is mounted adjacent to the low pressure cleaning blower. ~~and the alternate high pressure air compressor~~.

The other two junction boxes (JB1 & JB2) which are located adjacent to the power panel act as marshalling points for all signals to and from the control trailer.

## 2.7 Cabling Interconnections

The control panel, junction boxes JB1, JB2 and the interconnecting cables between them are fitted with multi pin plugs and sockets to permit fast and easy interconnections between the filter and the remote control trailer.

## 3. AUTOMATIC OPERATION

This instruction assumes that the plant is being started for the first time.

### 3.1 Pre Start Conditions

The normal shut down condition is with the filter isolated as follows:-

- Power supplies - off
- Inlet damper - closed
- Purge damper - closed
- Bypass damper - bypass
- Outlet/Control damper - open

Select local/remote handswitch HS9A to REMOTE (HS9A located local to the rotary manifold motor).

Close the main disconnect at the power panel # 1.

At the control panel:-

- Select all auto/manual handswitches to AUTO
- Select handswitch HS10 to ~~either~~ cleaning blower # 1. ~~or # 2 whichever is appropriate for the cleaning option in service~~
- Select handswitch HS13 to photohelic switch mode
- Select handswitch HS14 to "ON-LINE' mode

The system is now ready for automatic operation in the ON-LINE mode with the cleaning cycle being controlled by the pressure drop across the filter bags.

### 3.2 Start Up from the control panel

Select the ON/OFF handswitch (HS1) to "ON". The appropriate damper position indication lamps light up (white for closed, blue for open, both for mid position).

Also the purge air blower for the opacity monitor transmissometer. starts-up.

Depress the start pushbutton (PB2)

The plant comes into service in the bypass mode as follows:-

Inlet damper (BF1) opens
Purge damper (BF2) closed
Bypass damper (BF3) remains in bypass position
Outlet damper (BF4) open (governed by controller FC1)

The induced draft fan starts and draws dirty gas from the main duct through the inlet and bypass dampers and returns it to the main duct.

The appropriate indication lamps light up to show dampers positions and that the ID fan is running (green).

The system remains in the bypass mode until the temperature of the main ducts, as sensed by RTD1, reaches 250°F.

## 3.3 Operating Mode

One hour after the main duct temperature reaches 250°F, a time delay relay (2CR) energises and acting via interposing relays (3CR & 3xCR) causes the bypass damper (BF3) to rotate to the filter mode.

At the same time both the rotating manifold (M5) and the rotary valve airlock (M4) start running. The rotation monitor (14SS1 and 14SS2) for both of these devices are placed in service.

The filter is now in the automatic operating condition; dirty gas is drawn by the I.D. fan from the main duct via the inlet and bypass dampers, through the filter bags where it is cleaned and returned to the main duct via the outlet/control damper (BF4).

## 3.4 Flow Control

Gas flow through the filter is automatically maintained by the motorised outlet/control damper (BF4).

The gas flow can be directed by the motorised bypass damper (BF3) to pass through a manual knife gate valve and into the filter outlet duct. So that the bypass gas flow can be limited to a reasonable rate, the manual knife gate valve should never be set at more than approximately 1/2 open.

A differential pressure transmitter (PT1) monitors pressure changes across a flow measuring venturi which is located in the outlet duct. This transmitter (PT1) sends a 4-20mA signal, proportional to the flow, to the controller (FC1).

Output relays on the flow controller (FC1) control the motor on the outlet/control damper (BF4) opening it on falling pressure and closing it on rising pressure.

## 3.5 Cleaning Cycle

DIFFERENTIAL PRESSURE MODE

With the Photohelic Switching (PHSW)/TIMER handswitch HS13 selected to PHSW the cleaning cycle is initiated by the pressure drop across the filter bags.

When the pressure drop rises to 5" water gauge, a differential pressure photohelic switch (63PH) closes and, by means of interposing relays (3DP & 3CL) starts the duty cleaning blower. The blower maintains an air charge in the air reservoir which is mounted on top of the filter adjacent to the rotating cleaning manifold (M3).

A timer (TMR-2) has been adjusted so that whenever the pressure in the air reservoir reaches 12 psi a solenoid valve (25SV1) is energised and discharges air via the diaphragm valve, down through the rotating manifold nozzles. These short blasts of cleaning air blow down through the filter bags causing the dirt particles to fall into the hopper, where they are removed via the rotary airlock valve. These pulses of clean air continue until the pressure drop across the filter bags falls to 3" water gauge as sensed by the differential pressure gauge (63PH).

TIMER MODE

Alternatively, with the PHSW/TIMER handswitch HS13 selected to TIMER mode, the cleaning cycle is initiated by a timer TMR-1. In this mode timer TMR-1 is energised for 1 minute (adjustable) in every hour and replaces the differential pressure switch 63PH in the cleaning cycle.

## 3.6 Shutdown

There are two shutdown modes:

1 Controlled sequential shutdown
2 Emergency shutdown

CONTROLLED SEQUENTIAL SHUTDOWN

Depressing the stop pushbutton PB1 de-energises the start relays and energises the self retaining stop relays (5CR, 5xCR & T.D.63CR). This causes the inlet damper (BF1) to close and the purge damper (BF2) to open. At the same time the duty cleaning blower starts and the cleaning cycle commences.

After 12 minutes of cleaning, a time delay relay (62CR) picks up, de-energising the stop relays. This causes the bypass damper (BF3) to rotate to the bypass position and the purge damper (BF1) to close, and also shuts down the I.D. fan, the rotating cleaning manifold and the rotary airlock valve. The rotation monitors (14SS1 and 14SS2) are also taken out of service.

EMERGENCY SHUTDOWN

Anyone of the following abnormal conditions causes the plant to immediately shutdown.

Hopper level high (level detector 71DET)
Inlet temperature high (RTD2/temperature controller TC2)
Inlet temperature low (RTD2/temperature controller TC2)
Opacity high (opacity monitor 45 OP)
Filter very high differential pressure (pressure switch 63DP)
Loss of rotation-manifold (switch 14SS1)
Loss of rotation-rotary airlock valve (switch 14SS2)

When a fault condition occurs, a relay assigned to that fault energises and locks in. Normally closed contacts on the assigned relay break the circuit to the coil of the trip relay 94CR which in turn de-energises and causes the plant to shut down by tripping the start and interposing relays. Each fault condition is indicated by an assigned red lamp.

Once the cause of fault has been cleared the fault relay must be reset by pressing the reset pushbutton PB11.

4. MAINTENANCE

Daily - Tour upper and lower levels of baghouse and inspect visible components for good condition and cleanliness. At control panel in trailer, check to make certain there are no burned out bulbs. Observe operation of ID fan and pulse manifold blower. Listen for loose belts, etc.

Weekly - Inspect ID fan bearings and lubricate if necessary. Inspect fan belt tensions and adjust if necessary. Check for loose compressed air fittings on damper actuators.

# ORIMULSION TEST BURN
## AIR EMISSIONS CONTROL PILOT TESTING CONFIGURATION

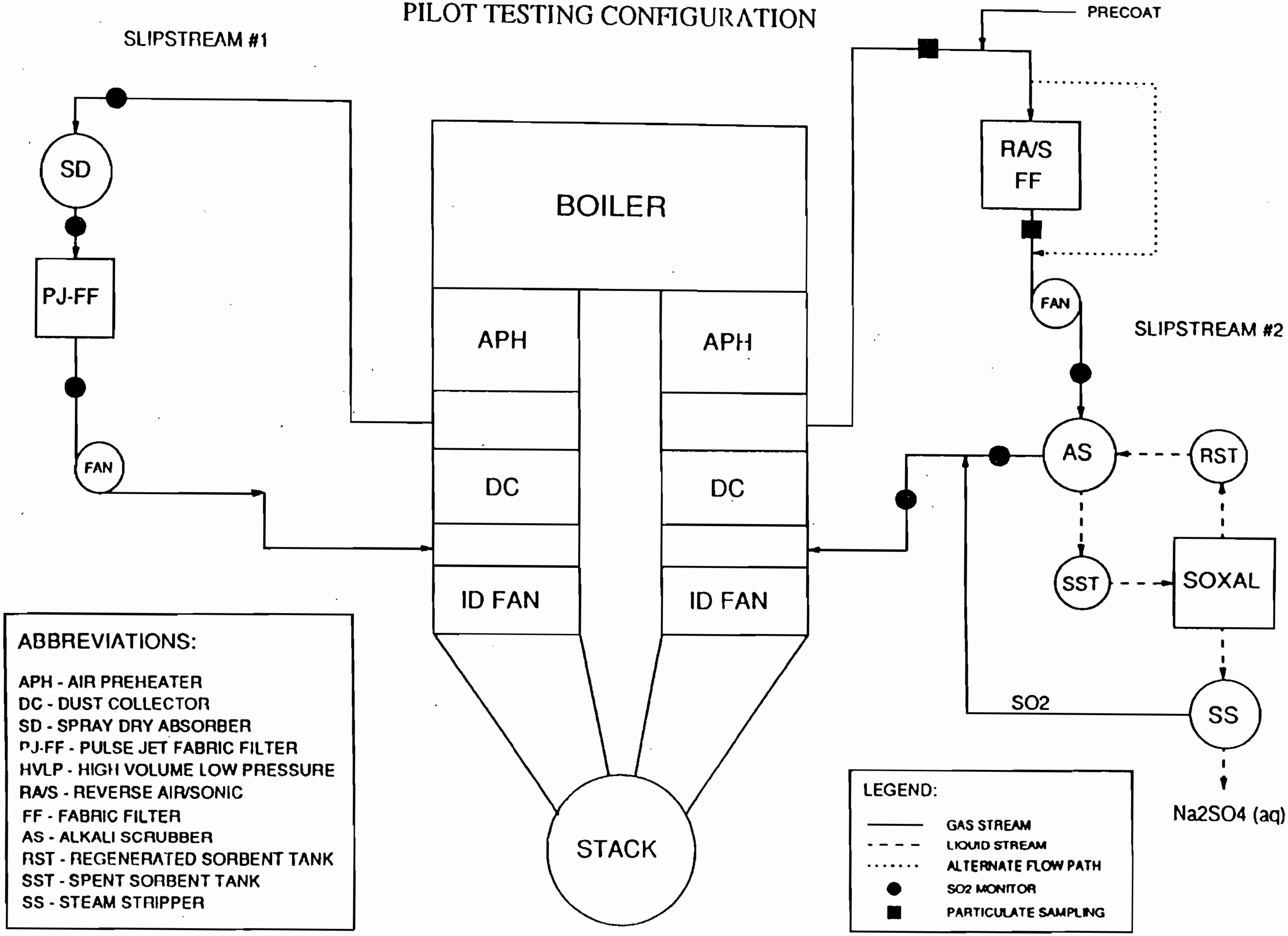
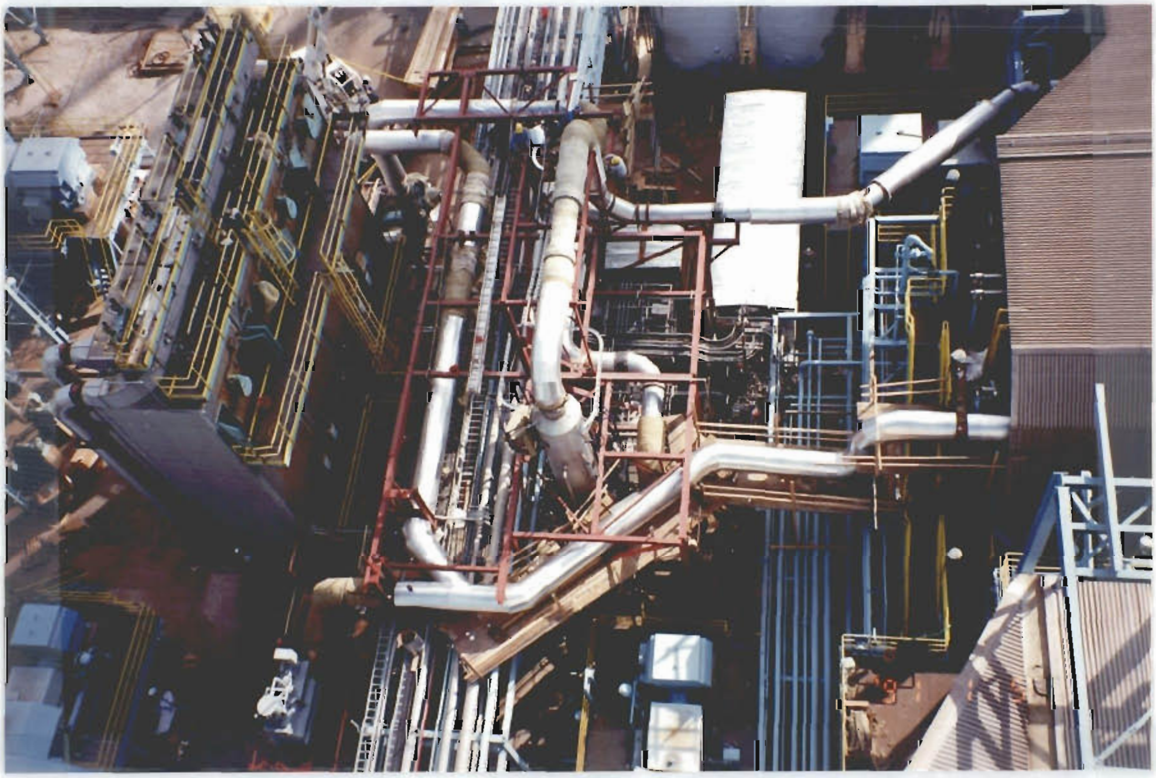
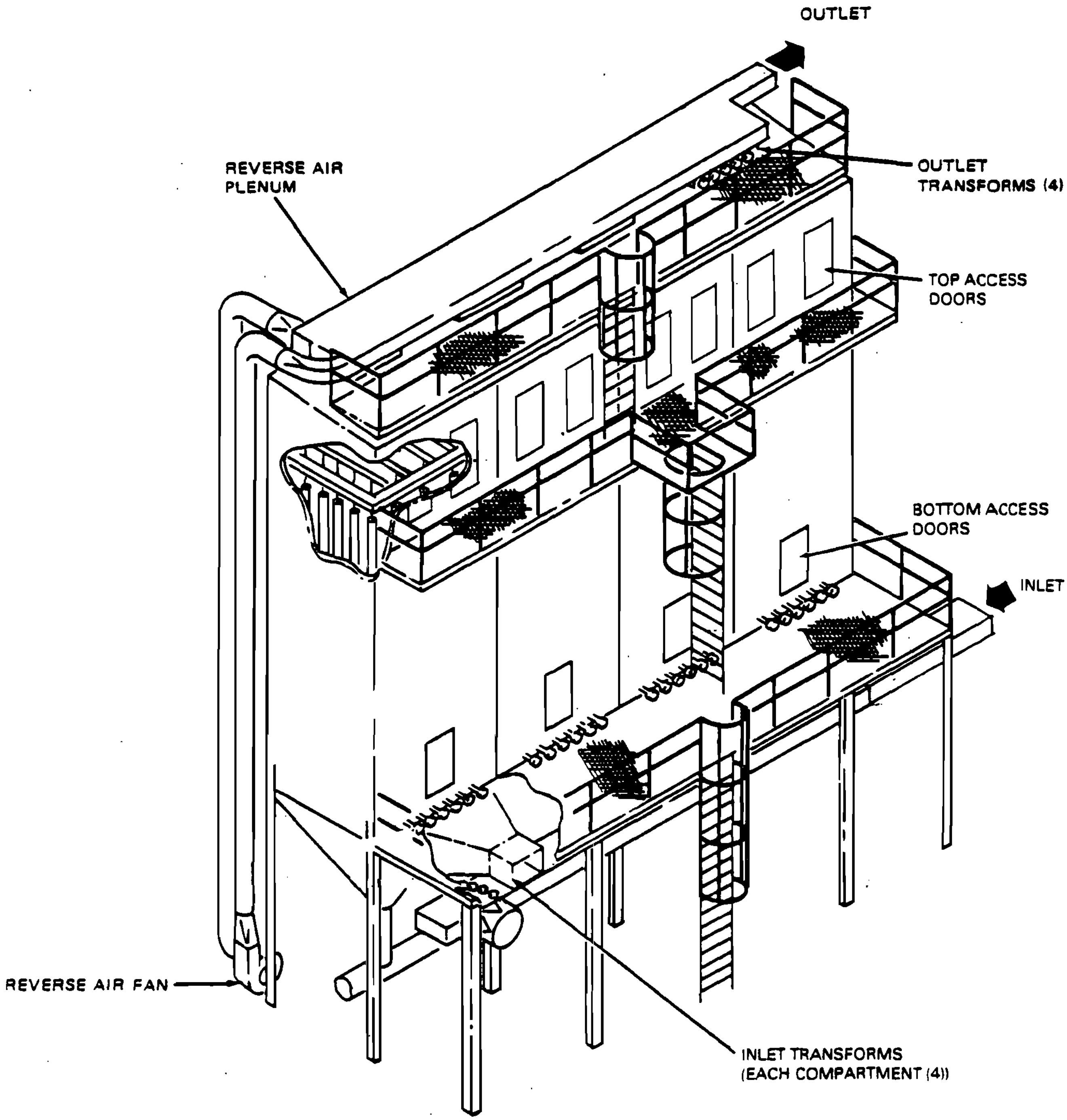



FIGURE 4.1
AIR EMISSIONS CONTROL PILOT TESTING CONFIGURATION



REVERSE-GAS FABRIC FILTER

FIGURE 4.2



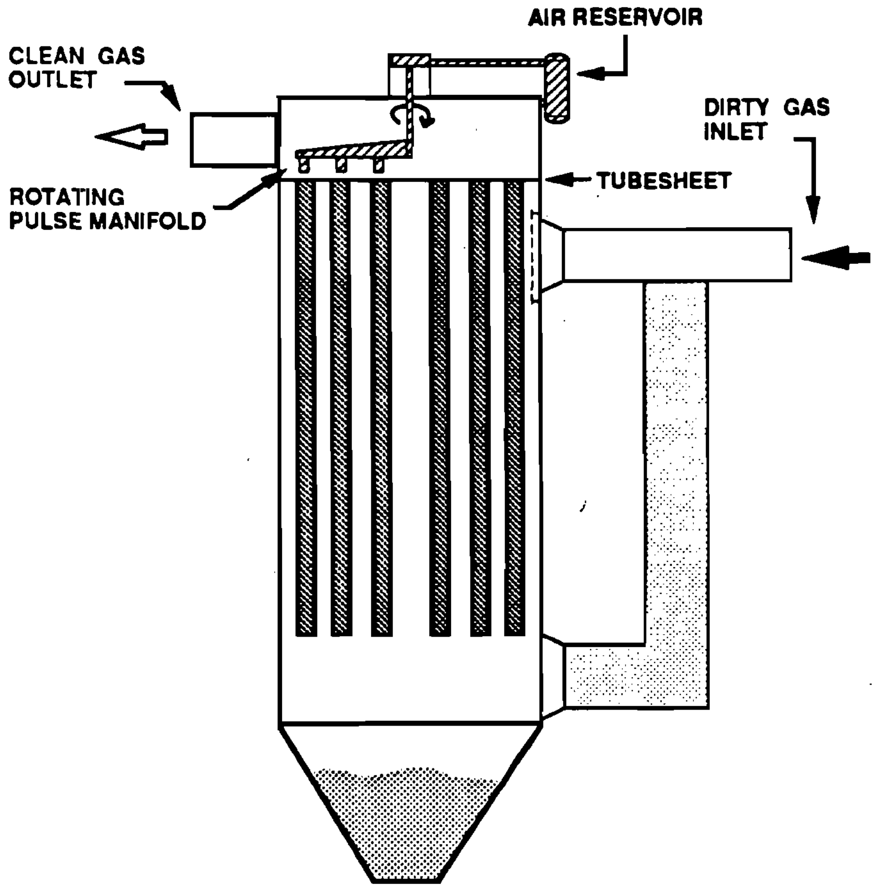

Schematic drawing of the four-compartment, Ecolaire reverse-gas fabric filter pilot plant.

REVERSE-GAS FABRIC FILTER DETAIL

FIGURE 4.3

PULSE-JET FABRIC FILTER

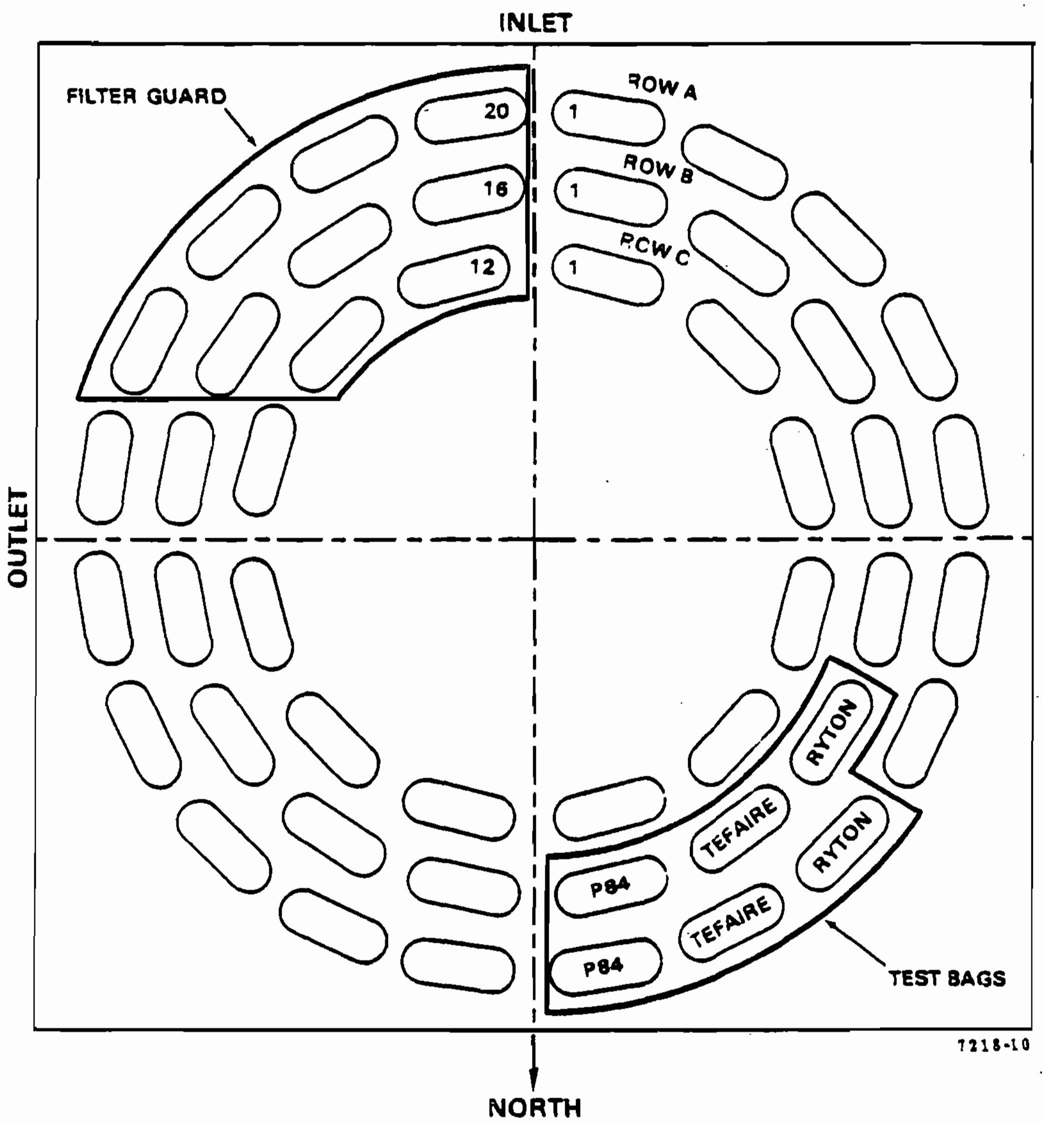
FIGURE 4.4




Schematic diagram of the pulse-jet fabric filter (PJFF) pilot plant. The unit is a low-pressure/high-volume pulse jet designed to filter 5000 acfm. The PJFF uses 48 bags that are arranged in concentric circles. Each bag is 20 feet long and 15.5 inches in circumference. The rotating manifold is supplied with air from a reservoir that is filled by a positive displacement blower to 12.5 psig. Nozzles in the manifold are aligned with each bag row and direct the pulse cleaning air to the bags.

PULSE-JET FABRIC FILTER DETAIL

FIGURE 4.5




Location of the test bags installed in the pulse-jet fabric filter pilot plant during the Orimulsion Test Burn Project. Huyglas needlefelt bags were installed in all locations not specifically marked (42 of 48 bags). DuPont Filter Guard was installed on the cages of nine Huyglas bags.

PULSE-JET FABRIC FILTER BAG ARRANGEMENT

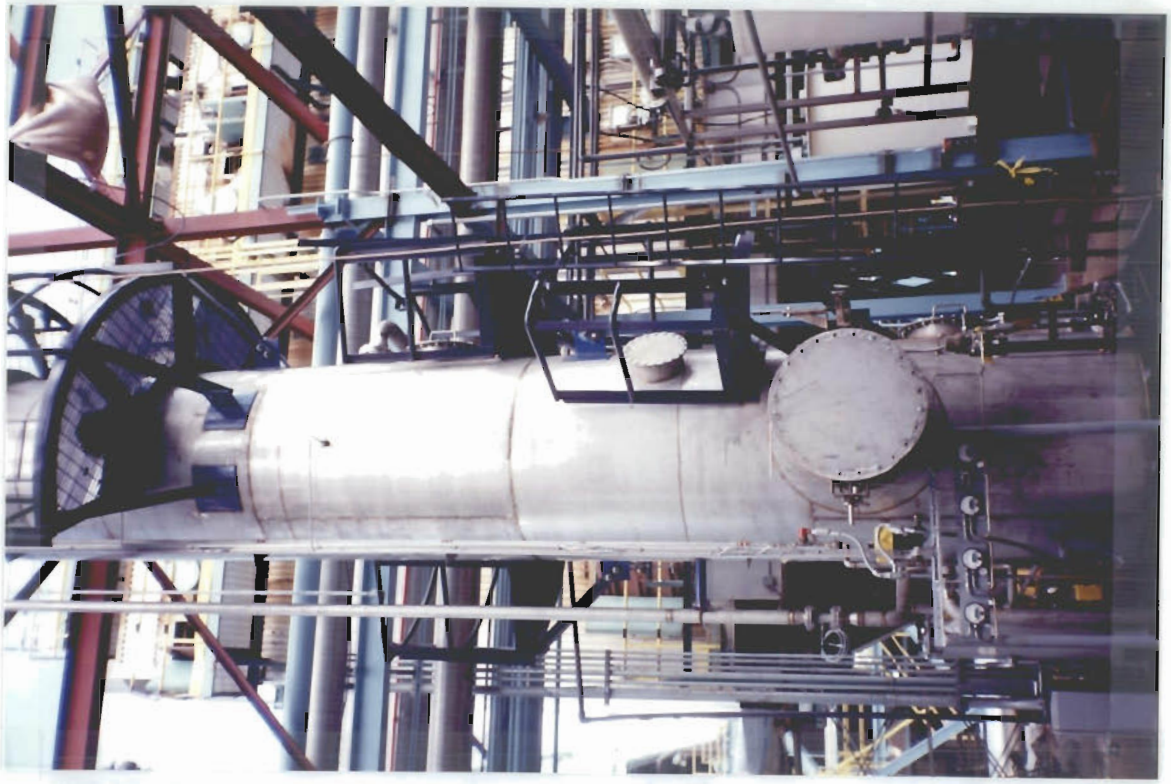
FIGURE 4.6

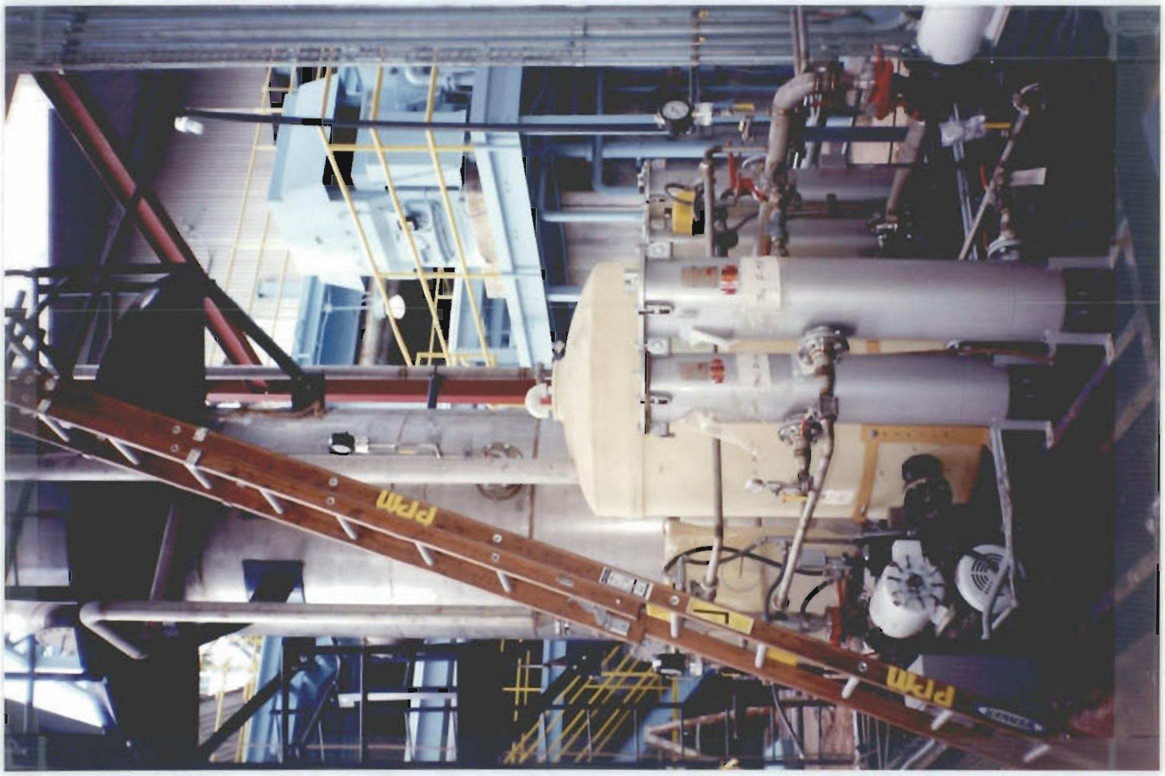
BAG PRECOAT INJECTION SYSTEM

FIGURE 4.7


FLY ASH HANDLING SYSTEM

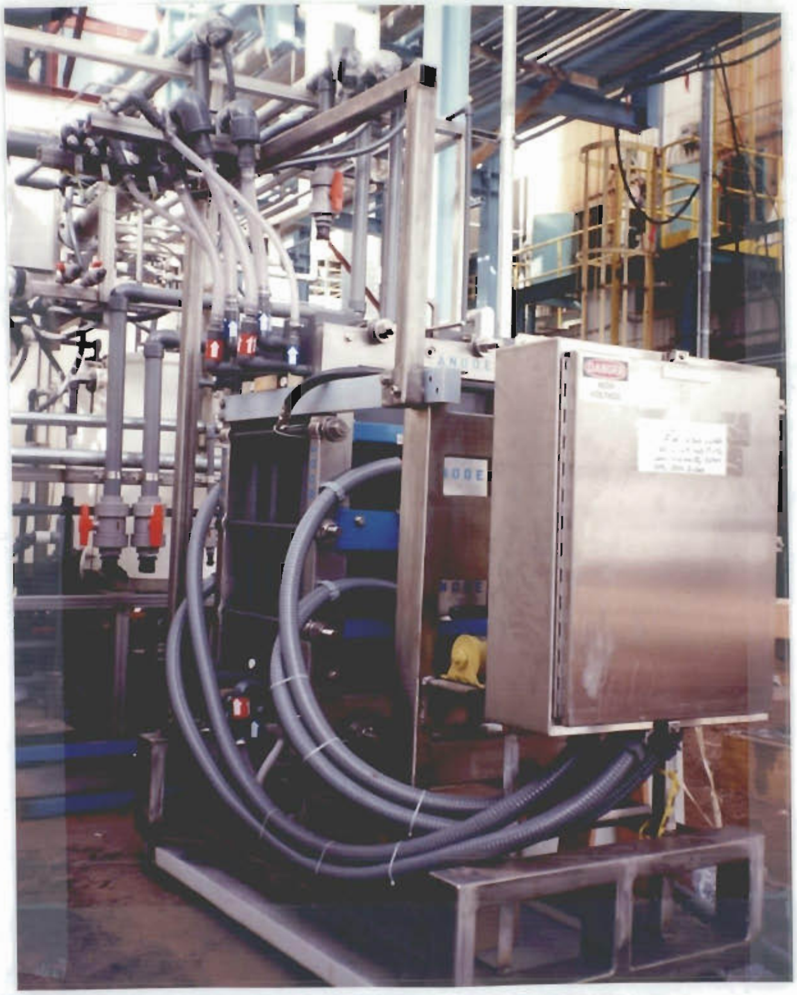
FIGURE 4.8





AIRPOL ALKALI SCRUBBER

FIGURE 4.9



AQUATECH SOXAL PROCESS

FIGURE 4.10

TABLE 5.1

BASELINE DATA FOR TEST BAG SAMPLES

| Fabric Type:<br>Style No.: | Huyglas<br>1701 | P84<br>M-C 84 Hi-Temp | Ryton/Rastex<br>RY02 | Tefaire<br>F-121 |
|---|---|---|---|---|
| **Fiber Content:** | | | | |
| Batt - | glass | copolyimide (P84) | sulfar (Ryton) | PTFE (Teflon) - 84%<br>glass -16% |
| Scrim - | glass | none present | PTFE (Rastex) | PTFE (Teflon) |
| Weight (oz/yd2): | 16.8 | 17 | 15.1 | 23 |
| Thickness (in) - ASTM D461 | 0.056 | 0.123 | 0.066 | 0.078 |
| Permeability<br>(cfm/ft2 @ 0.5" W.G.): | 40.6 | 35.6 | 46.3 | 30.5 |
| Mullen Burst (lb/in2, net): | 402 | 365 | 352 | 243 |
| Shrinkage; 2 h @ 400 F<br>(%, length x width): | N/A | 0.63 x 0.25 | 0.63 x 0.31 | 0.94 x 0.63 |
| Scrim Construction**: | | (Scrimless) | | |
| Weave - | Plain | | Plain | Mock Leno |
| Count (/inch, W x F) - | 18.5 x 17.5 | | 22 x 18 | 75 x 66 |
| Yarn (W x F) - | 75 1/3 | | 400 den | 400 den |
| Weight (oz/yd2) - | 10.3 | | 2.3 | 8 |
| Surface Finish: | None*** | Singed | None | None |

*Calculated based on the total composite felt weight less the scrim weight; actual LOI test on the felt showed 89.7% organic material (Teflon) and 10.3% residue (glass).

**As determined on scrim from delaminated felt samples, not on scrim prior to needling; scrim weight and nominal yarn size measured directly on the Huyglas, but weight of the Rastex and Teflon scrims were calculated from their counts assuming a nominal 400 denier yarn (standard production) was used for each.

***Commonly known as a "Plain" finish.

TABLE 5.2

REVERSE-GAS FABRIC FILTER OPERATING DATA

| Date 1991 | Time | Boiler Load MW | Gas/ Orimulsion %/% | Inlet Temperature F | A/C Ratio ft/min | Tubesheet dP in. H2O | Drag in. H2O/ ft/min | Comments |
|---|---|---|---|---|---|---|---|---|
| Apr-03 | 1900 | Baghouse placed in service | | | | | | a |
| Apr-05 | 1240 | 295 | 0/100 | 338 | 2.6 | 6.1 | 2.3 | |
| Apr-05 | 1330 | 295 | 0/100 | 338 | 2.7 | 6.3 | 2.3 | |
| Apr-07 | 1845 | 180 | 0/100 | 275 | 1.1 | 2.8 | 2.5 | |
| Apr-08 | 1230 | 365 | 0/100 | 379 | 3.3 | 7.1 | 2.1 | |
| Apr-09 | 1620 | 363 | 0/100 | 385 | 2 | 6.8 | 3.3 | |
| Apr-09 | 1800 | | | | | | | b |
| Apr-10 | 1000 | | | | | | | c |
| Apr-10 | 1400 | 162 | 0/100 | 305 | 3.4 | 6.1 | 1.8 | |
| Apr-12 | 1600 | Baghouse removed from service | | | | | | |
| | | | | | | | | |
| May-20 | 1315 | Baghouse placed in service | | | | | | |
| May-22 | 1200 | 162 | 40/60 | 288 | 2.2 | 4.1 | 1.9 | |
| May-23 | 1200 | 163 | 0/100 | | | 4.4 | | |
| May-23 | 1315 | 163 | 0/100 | 284 | 2.7 | 5.4 | 2 | |
| May-24 | 1730 | 162 | 58/42 | 297 | 2.9 | 6.1 | 2.1 | |
| May-25 | 940 | 324 | 60/40 | 349 | 3.2 | 6.5 | 2 | |
| May-27 | 1140 | 304 | 65/35 | 352 | 2.4 | 7.3 | 3.1 | |
| May-27 | 1210 | Sonic horns energized in all compartments | | | | | | |
| May-27 | 1240 | 303 | 65/35 | 354 | 2.5 | 5.2 | 2.1 | d,e |
| May-27 | 1340 | 304 | 65/35 | 342 | 2.3 | 6.3 | 2.7 | d |
| May-28 | 1010 | 363 | 60/40 | 374 | 3 | 8.6 | 3.2 | d |
| May-28 | 1030 | 363 | 60/40 | 378 | 3 | 7.5 | 2.9 | d,e |
| May-28 | 1720 | 371 | 60/40 | 392 | 2.9 | 8 | 3.6 | d |
| May-28 | 1730 | 371 | 60/40 | 392 | 2.9 | 7.2 | 3.4 | d,e |
| May-29 | 920 | 365 | 60/40 | 363 | 2.9 | 9.4 | 3.2 | d |
| May-29 | 940 | 366 | 60/40 | 363 | 3 | 8.3 | 2.9 | d,e |
| May-29 | 1720 | 385 | 63/37 | 385 | 2.9 | 10.4 | 3.6 | d |
| May-29 | 1740 | 385 | 63/37 | 385 | 2.6 | 8.9 | 3.4 | d,e |
| May-30 | 1240 | 337 | 0/100 | 401 | 2.7 | 9.1 | 3.3 | d |
| May-30 | 1630 | 382 | 0/100 | 385 | 2.6 | 9.2 | 3.5 | d |
| May-30 | 2140 | 370 | 0/100 | 383 | 2.5 | 9.5 | 3.6 | d |
| May-31 | 900 | 389 | 0/100 | 368 | 2.6 | 11 | 4.2 | d |
| May-31 | 925 | 389 | 0/100 | 363 | 2.7 | 10.6 | 3.9 | d,e |
| May-31 | 1300 | 379 | 0/100 | 383 | 2.5 | 10.2 | 4 | d |
| May-31 | 1700 | 390 | 0/100 | 376 | 2.5 | 10.9 | 4.4 | d |
| May-31 | 1800 | Baghouse removed from service | | | | | | |

Comments:
a.) Lower part of bags shaken by hand before startup.
b.) Sonic horns energized, however, little effect observed.
c.) Lower part of bags shaken by hand.
d.) Sonic horns in service during all cleaning cycles.
e.) Three consecutive cleanings prior to measurement.

TABLE 5.3

BAG RESIDUAL ASH LOADING

| SANFORD PULSE-JET FABRIC PERMEABILITY AND ASH LOADING COMPARISON | | | | | | |
|---|---|---|---|---|---|---|
| | | Residual Ash Loading (lb/ft$^2$) | | Permeability (cfm/ft$^2$ @ 0.5" WG) Used Bags (avg) | | New |
| Fabric | Bag # | Top | Bottom | Dirty | Washed | Fabric |
| Tefaire | B7 | 0.189 | 0.205 | 21.8 | 20.7 | 30.5 |
| Ryton/Rastex | B6 | 0.029 | 0.079 | 46.3 | 53.4 | 46.3 |
| Huyglas | | | | | | |
| With F.G. | A20 | 0.0049 | 0.0118 | 34.2 | 38.7 | 40.6 |
| w/o F.G. | C5 | 0.0056 | 0.0326 | 35.7 | 42.6 | 40.6 |

TABLE 5.4

MULLEN BURST STRENGTH COMPARISON DATA

| SANFORD PULSE-JET FABRIC STRENGTH COMPARISON | | | | |
|---|---|---|---|---|
| | | Mullen Burst Strength-lb/in$^2$ (net) | | |
| Fabric | Bag # | New | Used | % Loss |
| Telfaire | B7 | 243 | 222 | 8.6 |
| Ryton/Rastex | B6 | 352 | | |
| Typical | | | 241 | 32 |
| Top - At Wire Impressions | | | 174 | 51 |
| Top - At 2nd Horiz. Ring | | | 135 | 62 |
| Huyglas | | | | |
| with F.G.* | A20 | 402 | 79 | 80 |
| w/o F.G. | C5 | 402 | 78 | 80 |
| P84 | A10/B8 | 365 | Degraded | 100 |

* F.G. = Dupont's Filter Guard

## 6.0 REFERENCES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