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Dear Ms. Eskey:

Subject: Contract No. DE-AC22-90PC90361
Catalytic Fabric Filtration for Simultaneous NO_x and Particulate Control

Enclosed is a copy of the Quarterly Technical Progress Report for the subject contract, including the Key Personnel Staffing Report. The reporting period is April 1 through June 30, 1993.

The report is being distributed to DOE personnel and other project participants according to the attached distribution list. If you have any questions or require additional information, please call me at (701) 777-5222.

Sincerely,

Greg F. Weber

Greg F. Weber
Senior Research Manager
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**CATALYTIC FABRIC FILTRATION
FOR SIMULTANEOUS NO_x AND
PARTICULATE CONTROL**

*Quarterly Technical Progress Report
April 1 through June 30, 1993*

Contract No. DE-AC22-90PC90361

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August 1993

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CATALYTIC FABRIC FILTRATION FOR SIMULTANEOUS NO_x AND PARTICULATE CONTROL

1.0 INTRODUCTION

The University of North Dakota Energy & Environmental Research Center (EERC), Owens-Corning Fiberglas Corporation (OCF), and Raytheon Engineers & Constructors (RE&C), are conducting research to develop a catalytic fabric filter (CFF) for simultaneous NO_x and particulate control. Funding for the project is being provided by the U.S. Department of Energy/Pittsburgh Energy Technology Center (DOE/PETC), Consolidated Edison Company of New York Inc. (Con Edison), and the Empire State Electric Energy Research Corporation (ESEERCO). OCF is providing catalyst-coated bags, fabric samples, and technical support as a cost share.

The DOE/PETC funding was secured as a result of a competitive award from the DOE/PETC Advanced NO_x Control program. The objective of this program is to develop advanced concepts for the removal of NO_x from flue gas emitted by coal-fired utility boilers, or for the control of NO_x formation by advanced combustion modification techniques. Funded projects are required to focus on the development of technology that significantly advances the state of the art, using a process or a combination of processes capable of reducing NO_x emissions to 60 ppm or less. The concept must have successfully undergone sufficient laboratory-scale development to justify scale-up for further evaluation at the pilot scale (not to exceed 5 MW_e in size). Other requirements include production of a nonhazardous waste or a saleable by-product. The concept should have application to both new and retrofit coal-fired systems and show the potential for a 50% cost savings when compared to a commercial selective catalytic reduction (SCR) process capable of meeting the 60 ppm NO_x emission limit.

The EERC approach to meeting the program objective involves the development of a CFF for simultaneous NO_x and particulate control. The idea of applying either a permanent or throwaway catalysts to a high-temperature fabric filter for NO_x control is not new (1-4). However, advances at OCF have shown that a high-activity catalyst can be applied to a high-temperature woven glass cloth resulting in a fabric filter material that can operate at temperatures higher than commercially available, coated glass fabric. The NO_x is removed by catalytic reduction with ammonia to form nitrogen and water. The catalyst employed at this time is vanadium/titanium, but the exact catalyst composition and the unique method of applying the catalyst to high-temperature glass fabric are the property of OCF (5). Other catalyst options are being evaluated by OCF in order to improve catalyst performance and minimize catalyst cost.

Bench-scale experimental results have shown that over 90% NO_x removal can be achieved, that the catalyst/fabric has promising self-abrasion characteristics, and that the potential exists for substantially reduced cost compared to conventional SCR/fabric filtration technology (6,7). However, development of the technology requires further evaluation of air-to-cloth ratio effects, ammonia slip, SO₂ oxidation to SO₃, temperature cycling, catalyst-coated fabric preparation, fuel impacts, fabric cleaning (reverse-gas versus pulse-jet), catalyst life (poisoning and resistance to erosion), and filter performance/life (particulate control, differential pressure, and durability).

2.0 SCOPE OF WORK

The specific approach being used to address these issues is represented by the following:

- Task 1—Program Definition
- Task 2—Design and Construct Test Unit
- Task 3—Experimental Program and Data Reduction
- Task 4—Conceptual Design and Economic Evaluation
- Task 5—Test Unit Removal

Task 1, Program Definition, required preparation of a Project Management Plan. This document contains a detailed scope of work, project schedule, project budget; identifies key project personnel; and presents an appropriate QA/QC plan for the project. Task 2, Design and Construct Test Unit, was divided into three subtasks. Subtasks 2.1 and 2.2 involved the detailed design of the test facility on which the experimental program was performed, the construction of the test facility, and an operational shakedown of the system prior to initiating the experimental effort. Subtask 2.3 involved OCF preparation of the catalyst-coated fabric filters that are being evaluated in the experimental effort.

Task 3, Experimental Program and Data Reduction, has four subtasks. Subtask 3.1, Fundamental Testing, is intended as a support effort to the primary experimental test plan. This effort should supply information needed to understand the process mechanism thoroughly, allow screening of additional fabric samples, address the issue of catalyst poisoning, and generally support the pilot-scale effort. Subtask 3.2, Process Testing/Reverse-Gas System, was intended to evaluate process performance in a pilot-scale reverse-gas fabric filter, identify and optimize important process variables, and provide data for a conceptual design. Subtask 3.3, Process Testing/Pulse-Jet System, evaluated process performance in a pilot-scale pulse-jet fabric filter. Subtask 3.4, Fabric Durability Testing/Pulse-Jet System, will evaluate catalyst-coated fabric durability/performance for up to 12,000 hours in a slipstream pulse-jet baghouse.

Based on the results of Task 3, a technical and economic assessment of the CFF concept is currently being prepared in Task 4, Conceptual Design and Economic Evaluation. Task 5, Test Unit Removal, requires the identification of all major test facilities, equipment, instruments and hardware, and their condition, ownership, and proposed disposition.

The EERC is the primary contractor for the project and is responsible for the management/direction of all technical and administrative project activities. The EERC has, specifically, performed all work associated with Task 1, Subtasks 2.1 and 2.2, and will perform Tasks 3 and 5.

OCF performed and/or supervised all work associated with Subtask 2.3, including manufacturing the "S" glass fabric, coating the fabric, and manufacturing the filter bags for the reverse-gas and pulse-jet systems. This effort, as well as technical support, is being provided by OCF as a cost share to the project.

RE&C, as a subcontractor to the EERC, provided technical support for Task 1 and is currently working on Task 4. EERC personnel involved in the Task 3 effort and OCF personnel will provide input to RE&C Task 4 activities.

The project schedule is based on a project start date of October 1, 1990, and assumes a project duration of 36 months. Therefore, the planned project completion date was September 30, 1993. As of the preparation of this document, the project completion date has been extended through December 31, 1993. The three-month extension will permit the continuation of Subtask 3.4 through September 1993 at no additional cost to the project sponsors. As of June 30, 1993, planned experimental activities for Subtasks 3.2 and 3.3 have been completed. Bench-scale experimental work for Subtask 3.1 is continuing, and some additional bench-scale work is planned in support of Subtasks 3.2 and 3.3. Operation of the slipstream baghouse at the UND Steam Plant resumed in mid-April and continued through mid-May. Slipstream baghouse operation is expected to resume again in late July. Task 4 activities were ongoing during the past quarter.

3.0 GOALS AND OBJECTIVES

The overall objective of this project is the development of a catalyst-coated fabric filter for simultaneous NO_x and particulate control. The catalyst-coated fabric filter must provide high removal efficiency for NO_x and particulate matter. An acceptable bag and catalyst life must be demonstrated, and process economics must show a significant cost savings when compared to a commercial SCR process and conventional particulate control. Specific goals include the following:

- Reduce NO_x emissions to 60 ppm or less
- Demonstrate particulate removal efficiency of >99.5%
- Demonstrate a bag/catalyst life of >1 year
- Control ammonia slip to <25 ppm
- Show that CFF can achieve a 50% cost savings over conventional fabric filtration and SCR control technology
- Determine compatibility with SO₂ removal systems
- Show that the concept results in a nonhazardous waste product

Specific project activities to be completed during the past quarter (April through June 1993) were to include the following:

- Continue Subtask 3.1 – Fundamental Testing
- Continue Subtask 3.2 – Process Testing/Reverse-Gas System
- Complete Subtask 3.4 – Fabric Durability Testing/Pulse-Jet System

- Complete Task 4 – Conceptual Design and Economic Evaluation

4.0 ACCOMPLISHMENTS

4.1 Subtask 3.1 – Fundamental Testing

There were no bench-scale catalyst deactivation experiments completed this past quarter. The catalyst deactivation experiments planned as part of this effort have been delayed in order to complete some bench-scale fabric tests planned as a support activity for Subtask 3.2, 100- and 500-hr pilot-scale tests. Completion of the catalyst deactivation experiments is not anticipated before the end of August 1993.

Although not specifically related to this task, for convenience, there is information worth noting here concerning the Siemens on-line ammonia analyzer. The on-line ammonia analyzer that had been on loan to the Fossil Energy Research Corporation (FERC) has been returned to the EERC, along with a report of their findings (8). Their evaluation showed that the analyzer was prone to drift and produced an apparent ammonia reading when measuring an ammonia-free gas stream due to the presence of water vapor at levels consistent with natural gas firing. This observation is consistent with analyzer performance when used during pilot-scale catalyst-coated fabric tests at the EERC.

The apparent ammonia reading was reduced by increasing the operating temperature of the instrument from 65° to 80°C. However, in order to get the analyzer to zero properly while sampling an ammonia-free flue gas stream, FERC recommended that adjustments be made to the analyzer's optical coupler.

FERC also suggested that the sampling system be reconfigured. Specifically, the sample pump should be located downstream of the analyzer. Sample gas flow and pressures through the reference and sample cells could be controlled, with a precision vacuum gauge and rotameters. Even with the recommended adjustments to the analyzer, it will continue to be slow (roughly 20 min) in response to ammonia concentration changes.

As a result of its evaluation of the analyzer, FERC is considering the purchase of an instrument from Siemens, Inc., for use in a SCR pilot plant attached to a natural-gas-fired utility boiler. The Siemens instrument would be used in a control function, sampling the exit gas stream. A copy of the FERC report, "Evaluation of Siemens NH₃ Analyzer for Use at the Morro Bay SCR Pilot Plant," was attached to the June 1993 monthly status report.

The instrument operating temperature and location of the sample pump were specific concerns raised by EERC personnel when the analyzer was first purchased. At that time Siemens, Inc., personnel in the U.S. and Europe specifically stated that the instrument's operating temperature could not be increased and that the pump had to be installed upstream of the instrument. Before the analyzer is used again for on-line ammonia measurements at the EERC, these issues will be raised with Siemens, Inc.

4.2 Subtask 3.2 - Process Testing/Reverse-Gas System

Subtask 3.2 activities this past quarter included completion of routine reporting requirements, completion of two papers, hosting a project review meeting, performance of some limited bench-scale fabric testing, and further evaluation of the 500-hour test data. The first paper, entitled "Catalytic Fabric Filtration for Simultaneous NO_x and Particulate Control," requested by DOE/PETC, briefly summarizes project activities in the past year. After review comments from DOE/PETC personnel were addressed, the paper was submitted in final form on May 3, 1993, for preparation of bound conference preprints. The paper was presented at the Ninth Annual Coal Preparation, Utilization, and Environmental Control Contractors' Conference, which was held July 19-22, 1993, in Pittsburgh, PA. Copies of the paper were included as an attachment to the April Project Status Report.

The second paper, entitled "Pilot-Scale Evaluation of a Catalyst-Coated Fabric Filter for Simultaneous NO_x and Particulate Control in a Pulse-Jet Baghouse," was presented at the EPRI/EPA (Electric Power Research Institute/Environmental Protection Agency) 1993 Joint Symposium on Stationary Combustion NO_x Control. The paper summarized the results (NO_x reduction, ammonia slip, SO₂-to-SO₃ conversion, baghouse particulate emissions, and baghouse differential pressure) of the 500-hour pulse-jet test completed in December 1992. The symposium was held the week of May 23-27, 1993, in Miami Beach, Florida. Copies of this paper were distributed to project participants at the project review meeting on April 29, 1993.

A project review meeting was held on April 29, 1993, at the EERC to review the results of the 500-hour pulse-jet test completed in December and preliminary results from RE&C's work associated with Task 4. A representative of ABB Environmental Systems, James Wesnor, attended the project review meeting. He presented a brief overview of their low-emissions boiler concept and discussed how the CFF concept might fit. Other topics of discussion included the status of the slipstream baghouse operation at the University of North Dakota (UND) Steam Plant and the bench-scale experimental effort. Specific items of discussion during the meeting are addressed in various sections of this report.

The EERC project manager initiated some additional bench-scale experiments with fabric samples from filter bags used during the 100- and 500-hr pilot-scale tests, as well as two bags used during the performance/durability test at the UND Steam Plant. Evaluating these fabric samples in the bench-scale system should determine whether there are any differences in catalyst-coated fabric reactivity and determine the effect of exposure to flue gas as a function of time.

The experimental approach involved selecting one bag from each of the five pilot-scale pulse-jet test periods (three 100-hour and two 500-hour tests) and one new bag that has not been exposed to flue gas. Two bags were removed from the pulse-jet baghouse at the UND Steam Plant, representing 840 and 1642 hours of flue gas exposure. Three fabric samples were cut from each bag, representing the top, middle, and bottom of the bag. Each fabric sample was evaluated in the bench-scale system at a temperature of 650° to 660°F, an air-to-cloth ratio of nominally 3.8 ft/min, and an ammonia/NO_x molar ratio of 0.71 to 0.86. Inlet NO_x concentrations were about 700 ppm in the simulated flue gas. Other gas constituents included oxygen (3.8 vol%) with a nitrogen balance. Key

measurements included inlet and outlet NO_x and ammonia concentrations to determine NO_x reduction and ammonia slip. Figure 1 illustrates the experimental system used.

Preliminary results of the bench-scale fabric tests completed to date are summarized in Figure 2. Each set of data points (NO_x reduction and ammonia slip) represents an arithmetic average of three individual experiments, one experiment for each of the three fabric samples (top, middle, and bottom) removed from each bag tested. The results are presented in this manner, since variation in the data for a single bag was typically less than 2% NO_x reduction, and closure on the ammonia was typically 98%. Figures 3 and 4 summarize the results of the 500-hour pulse-jet test completed in December 1992 for comparison.

Four observations can be made with respect to these preliminary bench-scale data. First, the fabric samples tested from the two bags removed from the slipstream baghouse at the UND Steam Plant are demonstrating NO_x reduction and ammonia slip levels similar to those observed during the 500-hour test. These data imply that no significant decrease in catalyst reactivity occurred as a function of the number of hours of flue gas exposure for up to 1642 hours.

Second, all of the fabric samples that had been exposed to a flue gas stream in the pilot-scale pulse-jet baghouse during the 500-hour parametric tests are showing equivalent performance in the bench-scale system. Therefore, all of the catalyst-coated bags used during the two 500-hour tests completed appear to have comparable catalyst reactivity, indicating that differences observed during the 500-hour pilot-scale pulse-jet tests were probably a function of operating characteristics such as flue gas distribution through the bags. Nonuniform flue gas distribution occurred during part of the first 500-hour test because pulse nozzle plugging resulted in nonuniform bag cleaning.

The data point in Figure 2 representing fabric from pilot-scale test PTC-BT-430 indicates that it may be a little more reactive than the other fabric samples tested. This is indicated by slightly higher NO_x reduction and lower ammonia slip. One explanation may be that the fabric sample/bag tested was exposed to flue gas for <100 hours during pilot-scale pulse-jet tests. Based on results from the 100-hour and 500-hour tests, fabric reactivity decreased slightly after 100 hours of flue gas exposure. Further experiments may be completed with this fabric sample at lower ammonia-to- NO_x molar ratios to confirm the results.

Finally, the baseline data point represented by a new heat-treated fabric sample demonstrated NO_x reduction equivalent to that observed during the 500-hour test with clean fabric. However, the ammonia slip was significantly lower in the bench-scale test, 2% versus 7% of the inlet NO_x concentration. An explanation for the difference is not apparent at this time.

The planned pilot-scale experimental activities outlined in the original scope of work have been completed. Remaining activities will include routine reporting, preparation of papers and/or journal articles, additional bench-scale experimental work, and possibly some additional fabric analytical characterization.

Figure 1. Schematic of bench-scale reactor system.

Figure 2. NO_x removal and ammonia slip versus ammonia-to-NO_x molar ratio for bench-scale fabric screening tests.

Figure 3. NO_x removal and ammonia slip versus ammonia-to-NO_x molar ratio for gas-fired experimental periods during a 500-hour test.

Figure 4. NO_x removal and ammonia slip versus ammonia-to-NO_x molar ratio for coal-fired experimental periods during a 500-hour test.

4.3 Subtask 3.3 - Process Testing/Pulse-Jet System

Performance of the three 100-hour pulse-jet tests planned for this subtask were completed in July 1992, and the 500-hour test was completed in August 1992. Results were presented at a project review meeting in October 1992 and summarized in the Quarterly Technical Progress Report for the period July through September, 1992. Subtask 3.3 activities have been completed, with the exception of final reporting activities and the preparation of any papers or journal articles deemed appropriate.

4.4 Subtask 3.4 - Fabric Durability Testing/Pulse-Jet System

Prior to the system operation resuming in April 1993, the bags were removed, cleaned, inspected, reinstalled, and coated with a lignite fly ash resulting from one of the 100-hour reverse-gas pilot-scale tests completed in 1992. In addition, a new catwalk was designed and constructed to provide safe access to the top of the relocated baghouse. All of the thermocouple wire and conduit damaged as a result of boiler modifications were replaced to avoid future problems. Operation of the baghouse slipstream system at the UND Steam Plant resumed on April 15, 1993.

The slipstream baghouse operated for 798 hours from April 15 through May 18, 1993, resulting in 1489 cleaning cycles. As of June 30, 1993, the baghouse had accumulated 2440 hours of operating time. During the past quarter, the baghouse operated at an average flue gas temperature of 500° to 600°F, an air-to-cloth ratio of 3.5 to 4.5 ft/min, and a baghouse differential pressure of nominally 2 to 6 inches W.C. (water column).

Figure 5 presents baghouse mean temperature as a function of time for the entire 2440 hours of operation completed through May 18, 1993. Baghouse temperature is presented as an arithmetic mean value based on four thermocouples in the baghouse. The variability in baghouse mean temperature is the result of swings in boiler load. In general, the baghouse mean temperature is relatively low, ranging from 500° to 600°F, due to relatively low steam demand in the fall of 1992 and the spring of 1993. If the boiler had operated during the winter months (December, January, and February), average baghouse temperature would have been in the 600° to 700°F range. If low baghouse mean temperatures persist in August after resuming operation, the EERC Project Manager may increase the baghouse face velocity from 4 to 6 ft/min to increase average baghouse temperature.

Figure 6 presents baghouse face velocity as a function of time for the entire 2440 hours of operation. Initially baghouse face velocity was roughly 3.5 ft/min. After about 500 hours of operation, the face velocity was increased to 4 ft/min in an attempt to maintain baghouse mean temperature as average boiler load decreased. In November 1992, the face velocity was decreased to 3 ft/min in order to prevent the baghouse mean temperature from exceeding 700°F. In April 1993, the face velocity was again increased to 4 ft/min in order to maintain the baghouse mean temperature above 500°F. In order to determine face velocity, flue gas flow rates are monitored on a continuous basis by an annular flow element and verified twice daily by pitot measurements.

Figure 5. Steam plant baghouse mean temperature versus run hour.

Figure 6. Steam plant baghouse face velocity versus run hour.

Figure 7 presents baghouse differential pressure as a function of time for the entire 2440 hours of operation. For most of the 2440 hours of operation completed, the baghouse differential pressure has been effectively controlled at between 2 and 4 inches W.C. by using on-line cleaning. In May 1993, the ash loading to the baghouse was increased from < 2 gr/scf to > 2 gr/scf. This change resulted in a significant increase in the cleaning cycle frequency, and the bags were not cleaning efficiently. In order to prevent frequent cleaning and to improve bag cleaning, it was necessary to increase the cleaning cycle trigger point from 4 to 6 inches W.C.

Ash injection to augment the particulate mass loading from the stoker-fired boiler was continuous during the April/May operating period. The injection ash used in April was a lignite ash collected from the pilot-scale reverse-gas baghouse during catalyst-coated fabric tests completed in 1992. A bituminous ash collected from the pilot-scale pulse-jet baghouse during catalyst-coated fabric tests completed in 1992 was used in May.

Table 1 presents x-ray fluorescence (XRF) analysis results for a baghouse hopper ash sample collected in May. Primary components included silica, alumina, iron, and calcium, all reported as oxides. Although not indicated in the analysis, some level of sulfur would be expected. The sulfur number will be verified. The loss-on-ignition (LOI) for this sample was 6.19%, most likely the result of carbon carryover from the stoker-fired boiler.

Figure 7. Steam plant baghouse differential pressure versus run hour.

TABLE 1

XRF Analysis of Steam Plant Baghouse Hopper Ash, May 1993

Oxide	wt%	
SiO ₂	48.70	
Al ₂ O ₃	20.89	
Fe ₂ O ₃	12.74	
TiO ₂	1.25	
P ₂ O ₅	0.89	
CaO	9.62	
MgO	4.78	
Na ₂ O	0.79	
K ₂ O	0.34	
SO ₃	0.00	Loss-On-Ignition 6.19 wt%

In August and September, ash collected from a baghouse operating on one of the Steam Plant boilers will be used as the injection ash to the slipstream baghouse.

During the April/May operating period, the baghouse was cleaned as a function of differential pressure. The cleaning cycle trigger point was 4 inches W.C. in April, resulting in 250 cleaning cycles. In the first week of May, the cleaning cycle trigger point was increased from 4 to 6 inches W.C. in order to limit cleaning frequency to greater than or equal to 20 minutes. The increase in cleaning frequency resulted from an increase in the ash injection rate. Baghouse operation in May resulted in 1239 cleaning cycles. Total cleaning cycles as of June 30, 1993 number 3983. The pulse-air reservoir pressure was 43 psig, and the pulse duration was 0.1 seconds during the April/May operating period.

Particulate sampling was performed on April 27 and May 14, 1993. Tables 2 and 3 summarize EPA Method 5 and multicyclone sampling data, respectively, for the entire 2440 hours of operation completed. Ash injection was used during sampling periods in April and May to augment the boiler ash. Results showed that particulate collection efficiency ranged from 99.987% to 99.994% for four 2-hour sampling periods for an average inlet mass loading of 2.0 gr/scf. Measured outlet emissions ranged from 0.0001 to 0.0003 gr/scf.

Figure 8 presents baghouse emissions data generated using the APS sampling system. Total and respirable mass emissions were low, <0.1 mg/m³, except during cleaning cycles, which resulted in an emissions spike in the 0.2 to 0.5 mg/m³ range. Emissions based on integrated averages ranged from 0.01 to 0.04 mg/m³.

Multicyclone sampling in April/May indicated that roughly 80% of the fly ash entering the baghouse had an aerodynamic diameter of >8 microns. Figure 9 summarizes all of the multicyclone data resulting from operation of the pulse-jet baghouse

TABLE 2
Steam Plant Particulate Sampling Data

Test Date	Inlet, gr/scf	Outlet, gr/scf	% H ₂ O	% Efficiency
07-16-92	1.5542	---	8.1	---
07-16-92	---	0.0001	6.4	99.992
07-16-92	2.5491 ^a	---	7.1	---
08-20-92	1.7417	---	6.3	---
08-20-92	17.6786	---	7.3	---
08-20-92	---	2.5643	6.6	85.495
08-20-92	14.9548 ^a	---	6.1	---
10-29-92	4.0363	---	4.6	---
10-29-92	---	0.0008	5.2	99.986
10-29-92	---	0.0010	4.2	99.974
10-29-92	5.7311 ^a	---	3.7	---
11-19-92	3.1900	---	6.7	---
11-19-92	---	0.0007	6.0	99.979
11-19-92	---	0.0011	5.5	99.965
11-19-92	2.6910 ^a	---	4.8	---
04-27-93	1.6709 ^a	---	5.0	---
04-27-93	---	0.0001	5.4	99.994
04-27-93	---	0.0002	5.3	99.988
05-14-93	2.2604 ^a	---	6.2	---
05-14-93	---	0.0003	5.1	99.987
05-14-93	---	0.0003	5.1	99.987

^a Multicyclone sampling.

at the UND Steam Plant. The data show that during specific sampling periods, 74% to 97% of the fly ash entering the baghouse had an aerodynamic diameter of >10 microns.

Sampling was completed at the outlet of the baghouse to determine sulfur trioxide (SO₃) concentration. Results show SO₃ concentrations downstream of the baghouse to be less than 0.1 ppm.

TABLE 3
Steam Plant Multicyclone Data

07-16-92	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	9.24	6.07	3.27	2.23	0.93	---
Mass Collected, g	3.4958	0.3263	0.2812	0.1947	0.1327	0.0394
% Total Mass	78.21	7.30	6.29	4.35	2.97	0.88
Mass Less Than D ₅₀ , cumulative %	21.79	14.49	8.20	3.85	0.88	---
Total Mass Collected = 4.4700 g, Dust Loading = 2.5491 gr/scf, % Isokinetic = 99.0						
08-20-92	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	8.67	5.49	2.93	2.01	0.84	---
Mass Collected, g	27.9474	0.4742	0.1699	0.0940	0.0730	0.0261
% Total Mass	97.09	1.65	0.59	0.33	0.25	0.09
Mass Less Than D ₅₀ , cumulative %	2.91	1.26	0.67	0.34	0.09	---
Total Mass Collected = 28.7845 g, Dust Loading = 14.9548 gr/scf, % Isokinetic = 100.9						
10-29-92	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	10.27	7.09	3.88	2.61	1.08	---
Mass Collected, g	8.6404	0.0919	0.0397	0.0250	0.0278	0.0175
% Total Mass	97.72	1.04	0.45	0.28	0.31	0.20
Mass Less Than D ₅₀ , cumulative %	2.28	1.24	0.80	0.51	0.20	---
Total Mass Collected = 8.8424 g, Dust Loading = 5.7311 gr/scf, % Isokinetic = 90.6						

continued . . .

TABLE 3 (continued)
Steam Plant Multicyclone Data

11-19-92	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	8.35	5.14	2.72	1.89	0.79	---
Mass Collected, g	5.2629	0.1398	0.0464	0.0182	0.0071	0.0156
% Total Mass	95.86	2.55	0.85	0.33	0.13	0.28
Mass Less Than D ₅₀ , cumulative %	4.14	1.59	0.75	0.41	0.28	---
Total Mass Collected = 5.4901 g, Dust Loading = 2.691 gr/scf, % Isokinetic = 100.0						
04-27-93	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	8.50	5.17	2.73	1.91	0.80	---
Mass Collected, g	2.5941	0.2837	0.2670	0.1340	0.0817	0.0262
% Total Mass	76.60	8.38	7.88	3.96	2.41	0.77
Mass Less Than D ₅₀ , cumulative %	23.40	15.03	7.14	3.19	0.77	---
Total Mass Collected = 3.3867 g, Dust Loading = 1.6709 gr/scf, % Isokinetic = 102.9						
05-14-93	CY1	CY2	CY3	CY4	CY5	Backup Filter
D ₅₀ , μm	7.38	4.21	2.20	1.55	0.64	---
Mass Collected, g	4.4662	0.7465	0.1675	0.0423	0.0236	0.0225
% Total Mass	81.67	13.65	3.06	0.77	0.43	0.41
Mass Less Than D ₅₀ , cumulative %	18.33	4.68	1.62	0.84	0.41	---
Total Mass Collected = 5.4685 g, Dust Loading = 2.260 gr/scf, % Isokinetic = 103.3

Figure 8. Mass emissions and pressure drop as a function of time for the steam plant baghouse.

Figure 9. A summary of multicyclone data for ash collected in the steam plant baghouse.

The boiler from which the slipstream baghouse draws flue gas shut down on May 18, 1993, for routine maintenance. The boiler was expected to be back on-line before the end of June and was then scheduled to operate through the 1993/1994 heating season. However, a routine boiler inspection identified some unexpected grate damage that will extend the boiler maintenance shutdown through late July. Operation of the boiler and the slipstream baghouse was expected to resume the last week of July or the first week of August. Sufficient funding is available to operate the slipstream baghouse in August and September 1993. Operation of the slipstream baghouse in October will depend on the status of the project budget and boiler operating plans. The boiler may be shut down as early as October in order to accommodate the installation of a variable speed drive on the ID fan. Once the variable speed drive is installed, the boiler is expected to operate during the remainder of the 1993/1994 heating season.

Assuming the slipstream baghouse operates continuously during the months of August and September 1993, total accumulated operating hours will be roughly 3900. To achieve 12,000 hours of operation as originally planned, it would be necessary to operate the baghouse through at least September 1994 and secure the uncommitted portion of the original project budget.

4.5 Task 4 - Conceptual Design and Economic Evaluation

Raytheon Engineers & Constructors (RE&C) is working on the conceptual design and economic evaluation. Preliminary results from the new 500-MW_e plant case study were presented by RE&C at the April 29, 1993, project review meeting held at the EERC. During the meeting questions were raised concerning several of the assumptions used.

First, there was some discussion concerning the use of a 0.37-lb/MM Btu inlet NO_x level. Several project participants felt that a 0.30 value would be more appropriate. After the NO_x emissions data for low-NO_x burners presented at the EPA/EPRI NO_x symposium in May were reviewed, it was agreed that the 0.30-lb/MM Btu value would be more appropriate for the new plant case study. For the retrofit case study, an inlet NO_x level of 0.40-lb/MM Btu was selected, again, based on data presented for the retrofit of low-NO_x burners at the EPA/EPRI NO_x symposium held in May.

Some discussion concerned the selection of an outlet NO_x emission target other than strictly 80% NO_x reduction. Participants agreed to a 0.06-lb/MM Btu outlet NO_x emission level for the new plant case study. At this time, the retrofit case study assumes 80% NO_x reduction resulting in a 0.08-lb/MM Btu NO_x emission level.

Questions were raised concerning the assumptions made about bag length and air-to-cloth ratio. A 20-foot bag length was selected for both the CFF baghouse and the conventional pulse-jet baghouse. During the project review meeting, project participants felt that the CFF concept and the conventional pulse-jet baghouse should be evaluated on the same basis with respect to face velocity, with unknowns handled in the subsequent contingencies applied.

Upon further review, RE&C has recommended against using the same face velocity for both baghouses. The basis for their position is the differences in gas temperature and fabric type. Conventional cold-side pulse-jet fabric filter systems are using felted fabric with operating face velocities ranging from 3.5 to 4.5. Pilot-scale results with the catalyst-coated woven fabric have been focused on face velocities in the 3.0 to 3.5 range in order to adequately control ammonia slip. Therefore, the uncertainties associated with combining high-temperature woven glass (S2 glass) bags and hot-side baghouse operation with the need to minimize ammonia slip do not warrant evaluating the CFF concept at face velocities equivalent to those specified for conventional pulse-jet systems. At this time, the conceptual design and economic evaluation assumes gross face velocities of 3.44 and 3.7 ft/min, respectively, for the CFF concept and the conventional pulse-jet system.

RE&C is also modifying the process contingency to be used for the CFF concept. EPRI Technical Assessment Guidelines (TAG) specify a 20% or greater process contingency for technologies with only small pilot-scale experience. Rather than apply a 20% blanket process contingency to the overall CFF process, RE&C will modify the draft evaluation to apply the 20% contingency to only the flange-to-flange CFF and catalyst-coated bags. This is appropriate, since enlarging the baghouse and the catalyst-coated bags provide the only tangible process variables to affect performance. Therefore, the 20% process contingency will not be applied to duct work, the ammonia injection system, and other auxiliaries.

The retrofit case study is based on a 250-MWe plant firing the same eastern bituminous coal used in the new plant case study. In both cases, the fuel analysis represented the Blacksville bituminous coal used during the 500-hour pilot-scale tests completed at the EERC. Gas flow exiting the boiler is 1,268,000 acfm with an NO_x emission level of 0.4 lb/MM Btu (455 ppm, dry 3% O₂ basis). Particulate concentrations and flue gas temperature exiting the economizer are assumed to be 5.02 lb/MM Btu (3.05 gr/dscf) and 650°F, respectively. Boiler efficiency, excess air, air heater in-leakage,

and air heater exit temperature are assumed to be 88%, 20%, 15%, and 277°F, respectively.

A complete draft of the conceptual design and economic evaluation is expected to be available for initial review by EERC and DOE/PETC personnel in July. Subsequent to that initial review, the draft report will be forwarded to Jack Pirkey (Con Edison), Patrick Aubourg (OCF), and Aubrey Messing (ESEERCO) for review and comment.

5.0 KEY PERSONNEL STAFFING REPORT

Table 4 presents planned versus actual work hours for key EERC personnel involved in the CFF project through June 1993. Work hours reported for Mr. Robie of RE&C represent hours invoiced through May 1993.

TABLE 4
Planned Versus Actual Work Hours
for Key Project Personnel Through June 1993

Key Personnel	Planned Hours	Actual Hours	Percentage of Total Available Work Hours Used
Greg F. Weber	1930	1875	97
Dennis L. Laudal	2960	1091	37
Chris Robie	364	38	10

6.0 REFERENCES

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