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**CATALYTIC FABRIC FILTRATION
FOR SIMULTANEOUS NO_x AND
PARTICULATE CONTROL**

*Quarterly Technical Progress Report
for the period January 1 – March 31, 1994*

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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) have been conducting research to develop a catalytic fabric filter (CFF) for simultaneous NO_x and particulate control. Funding for the project was 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 provided 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 scaleup 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 salable 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 catalyst 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-coated fabric has promising self-abrasion characteristics, and that the potential exists for substantially reduced cost compared to conventional SCR and fabric filtration technologies (6, 7). However, development of the technology required 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 life and performance (particulate control, differential pressure, and durability).

2.0 SCOPE OF WORK

The specific approach 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, and project budget; identifies key project personnel; and presents an appropriate quality assurance/quality control (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 initiation of the experimental effort. Subtask 2.3 involved OCF preparation of the catalyst-coated fabric filters that were evaluated in the experimental effort.

Task 3, Experimental Program and Data Reduction, had four subtasks. Subtask 3.1, Fundamental Testing, was intended as a support effort to the primary experimental test plan. This effort supplied 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, evaluated catalyst-coated fabric durability and performance for more than 5000 hours in a slipstream pulse-jet baghouse.

Based on the results of Task 3, a technical and economic assessment of the CFF concept, Task 4, Conceptual Design and Economic Evaluation, was completed. 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 and 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 Task 3 and will perform Task 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, was 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 completed work on Task 4. EERC personnel involved in the Task 3 effort, and OCF personnel provided input to RE&C Task 4 activities.

The project schedule was based on a project start date of October 1, 1990, and originally assumed a project duration of 36 months. Therefore, the planned project completion date was September 30, 1993. As of the preparation of this document, authorization has been given to extend the project completion date through August 31, 1994. The eleven-month extension permitted the continuation of Subtask 3.4 into December, 1993, and allowed participation in a July 1994 contractors' review meeting at no additional cost to the project sponsors. As of the preparation of this report, planned experimental activities for Subtasks 3.1, 3.2, 3.3, and 3.4 have been completed. Task 4 activities were completed in early November 1993 and Task 5 should be completed next 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 (January – March 1994) were to include the following:

- Complete Subtask 3.2 – Process Testing/Reverse-Gas System
- Complete Subtask 3.3 – Process Testing/Pulse-Jet System
- Complete Subtask 3.4 – Fabric Durability Testing/Pulse-Jet System
- Complete Task 5 – Test Unit Removal

4.0 ACCOMPLISHMENTS

4.1 Subtask 3.1 – Fundamental Testing

All of the planned bench-scale fabric heat treatment, catalyst deactivation, and fabric screening experiments have been completed. The activities and results have been documented in the final project report. Conclusions developed from the data include those listed below.

4.1.1 Heat Treatment

- Catalyst-coated fabric must be heat-treated to remove a fugitive lubricant used in the bag-manufacturing process. Bench-scale testing with three fabric types determined that 4 hours of exposure to a clean flue gas stream containing 2–4 vol% O₂ at 700°–725°F was adequate. This approach was effectively used to heat-treat catalyst-coated bags prior to pilot-scale tests.
- Heat treatment at flue gas temperatures exceeding 750°F resulted in a permanent loss of catalyst reactivity, and flue gas temperatures below 650°F were generally inadequate.
- Whether the catalyst-coated fabric could be effectively heat-treated with a dirty flue gas (SO₂ and fly ash) is unknown. Development of a heat treatment procedure for commercial use is necessary.

4.1.2 Catalyst Deactivation

- Strong acids (0.1 M HCl and H₂SO₄) and a strong base (0.1 M NaOH) were found to destroy catalyst reactivity on clean fabric samples. However, in the case of the acid-coated fabric, thoroughly washing the samples with water resulted in a complete recovery of catalyst reactivity. These results imply that the strong base chemically destroys catalyst reactivity, while the acid merely interferes with the catalyst site.
- Strong acids and a strong base were found to destroy catalyst reactivity on used fabric samples having a light residual ash layer. Although the degree of catalyst reactivity loss was greater for residual ashes containing greater concentrations of alkali, the end result in all cases was a significant decrease in catalyst reactivity, which would require catalyst-coated bag replacement.
- Exposure of clean catalyst-coated fabric to a severe moisture dew point showed little or no effect on catalyst reactivity. However, for used fabric samples having a light residual ash layer, catalyst reactivity was permanently reduced to a level requiring replacement of the catalyst-coated bags.
- Catalyst-coated fabric samples coated with any one of several chemical forms of alkali (Na, Ca, and K) and then exposed to a severe moisture dew point demonstrated a significant loss of catalyst reactivity. Independent of chemical form, sodium had a greater effect than calcium, and calcium a greater effect than potassium, consistent with the increasing Brønsted acidity of the ions.

4.1.3 Bench-Scale Screening Tests

- Bench-scale catalyst-coated fabric screening tests with newly developed woven fabric samples prepared by OCF have shown the potential for improved catalyst reactivity when compared to catalyst-coated woven fabric used during the pilot-scale tests. In one case, a fabric sample prepared using 10 coats of catalyst rather than 7 increased NO_x reduction and reduced ammonia slip by over 60%. Assuming future bench- and pilot-scale tests substantiate the improved performance of the new catalyst-coated fabric, 80% NO_x reduction could be achieved with an ammonia slip of < 10 ppm or 95% NO_x reduction could be achieved with an ammonia slip of < 20 ppm.

4.2 Subtask 3.2 - Process Testing/Reverse-Gas System

The planned reverse-gas pilot-scale experimental activities outlined in the original scope of work have been completed. Subtask 3.2 activities and results have been documented in the final project report. Conclusions developed from the data include the following:

- Pilot-scale 100-hr fabric screening tests demonstrated that the 22-oz/yd² woven S-glass fabric prepared using 7 coats of a vanadium-titanium catalyst and applied using an organic-based coating process resulted in higher NO_x reduction and lower ammonia slip than the other four catalyst-coated fabric types tested. However, differences observed between the 14- and 22-oz/yd² fabric prepared using the same catalyst and organic-based coating process may be simply the result of greater catalyst concentration on the 22-oz/yd² fabric. Therefore, further development or testing of the catalyst-coating process would be appropriate to optimize the quantity of the catalyst that can be effectively applied to an S-glass fabric.
- Although the aqueous-based catalyst-coating process did not perform nearly as well as the organic-based catalyst-coating process, the potential advantages of the aqueous-based process with respect to reduced costs and avoiding the handling and emissions issues inherent in the use of organic solvents warrant further developmental consideration.
- During 100-hr test periods using the reverse-gas baghouse, 90% NO_x reduction and < 25-ppm ammonia slip were demonstrated. Air-to-cloth ratio had a significant effect on catalyst-coated fabric performance. An air-to-cloth ratio of < 4 ft/min and a flue gas temperature of 650°–700°F were necessary to achieve 80% NO_x reduction and adequately control ammonia slip.
- Flue gas temperature also had an effect on catalyst-coated fabric performance. As flue gas temperatures were decreased from 650°F, ammonia slip increased and NO_x reduction decreased, while temperatures of > 750°F are known to permanently deactivate the catalyst.
- The pilot-scale data from the 100-hr reverse-gas test periods indicate that fuel type (bituminous coal, subbituminous coal, and lignite) may have some effect on NO_x reduction and ammonia slip. However, the short duration of these tests and

range of operating parameters experienced prevents the development of specific conclusions.

- Baghouse differential pressure was controlled at 2–10 in. W.C., during the 100-hr coal-fired reverse-gas test periods at all air-to-cloth ratios tested. Baghouse differential pressure was controlled using off-line cleaning during reverse-gas tests.
- Particulate collection efficiency was >99.5% for both the 14- and 22-oz/yd² woven S-glass fabric for all 100-hr coal-fired test periods when the ammonia was turned off. However, with the ammonia on, the particulate collection efficiency for tests with high ammonia slip (>40 ppm) was lower because of ammonium sulfate or bisulfate formation on the particulate sampling filters.

A draft of the final project report was submitted to project participants for review in mid April 1994. Remaining Subtask 3.2 activities will include routine reporting, preparation of papers and/or journal articles deemed appropriate, completion of the final project report in response to review comments, and participation in the PETC contractor's review meeting in July 1994.

4.3 Subtask 3.3 – Process Testing/Pulse-Jet System

The three 100-hr pulse-jet tests planned for this subtask were completed in July 1992, and the 500-hr test was completed in August 1992. Subtask 3.3 activities and results have been documented in the final project report. Conclusions developed from the data include the following:

- During 100-hr test periods using the pulse-jet baghouse, 90% NO_x reduction and <25-ppm ammonia slip were demonstrated. Air-to-cloth ratio had a significant effect on catalyst-coated fabric performance. An air-to-cloth ratio of <4 ft/min and a flue gas temperature of 650°–700°F were necessary to achieve 80% NO_x reduction and adequately control ammonia slip.
- The pilot-scale data from the 100-hr reverse-gas test periods indicate that fuel type (bituminous coal, subbituminous coal, and lignite) may have some effect on NO_x reduction and ammonia slip. However, the short duration of these tests and range of operating parameters experienced prevents the development of specific conclusions.
- In order to minimize the effect of fly ash characteristics on CFF performance, future development activities should evaluate a catalyst-coated S-glass felt. The catalyst-coated felt would not be affected by pinholing to the degree a woven fabric is affected. Therefore, dust cake characteristics, such as pinholes, would have less effect on NO_x reduction and ammonia slip.
- Results from the 100-hr oil-fired test were similar to those from the 100-hr coal-fired tests. However, NO_x reduction was slightly lower and ammonia slip, as a percent of inlet NO_x concentration, was slightly higher. Lower NO_x reduction and higher ammonia slip probably resulted from a very low fly ash loading entering

the baghouse, resulting in very little dust cake development and a low operating differential pressure (< 3 in. W.C.).

- Particulate collection efficiency was > 99.5% for the 22-oz/yd² woven S-glass fabric for all 100-hr coal-fired test periods when the ammonia was turned off. However, with the ammonia on, the particulate collection efficiency for tests with high ammonia slip (> 40 ppm) was lower because of ammonium sulfate or bisulfate formation on the particulate sampling filters.
- Baghouse differential pressure was controlled at reasonable levels, 4–8 in. W.C., during the 100-hr coal-fired test periods at all air-to-cloth ratios tested. Baghouse differential pressure was controlled using on-line cleaning during pulse-jet tests.
- N₂O concentrations in the flue gas were measured at both the inlet and outlet of the CFF baghouse during several test periods to verify that nitric oxide and nitrogen dioxide were not being converted to N₂O. For all coals tested, N₂O concentrations were < 10 ppm at the CFF baghouse inlet and outlet.
- Based on the catalyst-coated fabric and baghouse hopper ash samples analyzed, there does not appear to be any significant catalyst loss or erosion occurring that would affect performance with respect to NO_x reduction or ammonia slip or create concern with respect to fly ash disposal. This observation was made during the 100-hr and 500-hr pilot-scale parametric tests as well as during the fabric durability test, where catalyst-coated fabric was exposed to flue gas in a pilot-scale baghouse for 5136 hours. Therefore, the CFF concept meets the DOE/PETC Advanced NO_x Control objective concerning the production of a nonhazardous waste product. However, vendors of both the CFF concept and conventional SCR systems will need to address the recycle and/or disposal of spent catalyst in commercial applications.
- Measurements were made to determine SO₃ concentrations downstream of the CFF baghouse with the ammonia injection system turned off to avoid interference. Results from the 100-hr and 500-hr tests while various fuels were fired (oil, bituminous coal, subbituminous coal, and lignite) demonstrated that the CFF was not oxidizing SO₂ to SO₃.
- The 500-hr bituminous coal-fired tests demonstrated that the reactivity of the catalyst-coated fabric decreased slightly during the first 100 hours of operation. After 100 hours, performance was stable, demonstrating 80% NO_x reduction, with an ammonia slip of 7.5% of the inlet NO_x concentration at an air-to-cloth ratio of 3–3.5 ft/min. Assuming an inlet NO_x concentration of 300–400 ppm, the resulting ammonia slip would be 20–30 ppm. These results demonstrate the potential to meet the DOE/PETC Advanced NO_x Control Program objective of reducing NO_x emissions to 60 ppm or less.
- Analysis of baghouse hopper ash collected during the 500-hr test showed that ammonia concentrations in the ash were < 100 µg/g for test periods when NO_x reduction was 80%–90%.

- Particulate collection efficiency was typically >99.9% during the 500-hr tests, easily meeting the current New Source Performance Standard of 0.03 lb/MMBtu. Exceptions were observed when ammonia slip exceeded 40 ppm. Baghouse differential pressure was easily controlled between 4 and 6 in. W.C. using on-line pulse cleaning.

Remaining Subtask 3.3 activities will include routine reporting, preparation of any papers or journal articles deemed appropriate, and completion of the final project report in response to review comments.

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

The planned pilot-scale experimental activities outlined in the original scope of work have been completed. Subtask 3.4 activities and results have been documented in the final project report. Conclusions developed from the data include the following:

- A single set of nine catalyst-coated DE992 bags were evaluated in a slipstream baghouse for 5136 hours, resulting in 13,820 cleaning cycles, while subbituminous coal was fired in a stoker-fired boiler at the UND Steam Plant. Supplemental ash injection was used to augment fly ash from the stoker-fired boiler. Baghouse operating conditions included flue gas temperatures of 500°–700°F, filter face velocities of 3–5 ft/min, and differential pressures of 2–6 in. W.C. There were no catalyst-coated fabric failures as a result of the 5136 hours of normal baghouse operation. Because of project funding limitations and steam plant downtime, the project objective of demonstrating a bag/catalyst life of >1 year was not achieved. However, there were no data collected or observations made that would indicate a bag/catalyst life of <1 year.
- Particulate collection efficiency for the slipstream baghouse, as determined by a modified EPA Method 5, ranged from 99.96% to >99.99% for inlet mass loadings ranging from 1.5–5.7 gr/scf. An inlet mass loading of 3 gr/scf resulted in cleaning cycle frequencies of 20–30 minutes.
- Differential pressure across the slipstream baghouse was effectively controlled using on-line cleaning, a reservoir pulse pressure of 43 psig, and a pulse duration of 0.1 seconds. These pulse system conditions resulted in a pulse volume of roughly 0.3 ft³ per bag.
- Sampling at the outlet of the slipstream baghouse demonstrated that the catalyst-coated bags did not oxidize SO₂ to SO₃. Measured SO₃ concentrations were <1 ppm. These data are consistent with the results observed for the 100- and 500-hr pilot-scale parametric tests.
- Data from MIT flex, Mullen burst, and bench-scale reactivity tests demonstrated that catalyst-coated fabric strength and reactivity did not degrade with time. Fabric samples tested represented 840, 1642, and 5136 hours of flue gas exposure.

4.5 Task 4 - Conceptual Design and Economic Evaluation

Raytheon Engineers & Constructors (RE&C) completed work on the conceptual design and economic evaluation in October 1993. Task 4 activities and results have been summarized in the final project report. A copy of the Task 4 report prepared by RE&C is included in Appendix D of the final project report. Conclusions developed from the evaluation include the following:

- The economic evaluation for the 500-MW new plant case showed that the total installed plant investment for the CFF concept was 20.6% higher than the total installed plant investment for the SCR/pulse-jet fabric filtration (PJFF) combination, \$152/kW versus \$126/kW. The capital cost differential resulted from several factors, with the single most significant factor being the duct work requirements associated with installation of a hot-side baghouse. Other elements contributing to the differential in total installed equipment costs included the baghouse, the air heater upgrade, the ammonia injection system, and the bag cages.
- On a levelized cost basis, there was no real difference between the CFF and the SCR/PJFF concepts, 6.1 versus 6.05 mills/kWh, respectively, for the new 500-MW plant. Levelized costs for the CFF are driven by catalyst-coated bag replacement costs. Elements driving levelized costs for the SCR/PJFF included SCR catalyst replacement costs and the additional induced-draft (ID) fan power requirements to offset pressure losses across the SCR reactors and the PJFF.
- Cost sensitivity analysis for the CFF showed that the cost of the catalyst-coated bags has the strongest effect on overall economics, capital and levelized costs, for the new 500-MW plant. Based on the assumptions used in the evaluation, the individual bag cost would have to be reduced from \$250/bag to \$108/bag in order to achieve a capital cost break-even point for the CFF and SCR/PJFF.
- The economic evaluation for the 250-MW retrofit plant case showed that the total installed plant investment for the CFF concept was 8.0% higher than the total installed plant investment for the SCR/PJFF combination, \$215/kW versus \$199/kW. In this case, no single factor contributed significantly to the differential. Factors contributing to the higher CFF total installed plant investment cost included the baghouse, bag cages, ammonia injection system, and the air heater upgrade.
- On a levelized cost basis, there was no real difference between the CFF and the SCR/PJFF concepts, 9.23 versus 9.36 mills/kWh, respectively, for the 250-MW retrofit. Levelized costs for the CFF are driven by catalyst-coated bag replacement costs. Elements driving levelized costs for the SCR/PJFF included SCR catalyst replacement costs and the additional ID fan power requirements to offset pressure losses across the SCR reactors and the PJFF.
- Cost sensitivity analysis for the CFF showed that the cost of the catalyst-coated bags has the strongest effect on overall economics, capital and levelized costs, for the 250-MW retrofit. Based on the assumptions used in this evaluation, the

individual bag cost would have to be reduced from \$250/bag to \$155/bag in order to achieve a capital cost break-even point for the CFF and SCR/PJFF.

- Based on the economic evaluation, the CFF concept does not meet the Advanced NO_x Control Program objective of a 50% cost savings when compared to a commercial SCR process capable of meeting the 60-ppm NO_x emission limit. However, this objective was developed in 1989, and estimated SCR costs have decreased significantly since then. In fact, shortly before the CFF economic evaluation was completed, the estimated cost of SCR catalyst was reduced from \$400/ft³ to \$300/ft³. Therefore, the development of a new, highly efficient NO_x control process that is 50% less costly than a conventional SCR system is highly unlikely.
- The conceptual design and economic evaluation completed by RE&C indicates that the CFF can be economically competitive with the SCR/PJFF, but CFF costs must be reduced in order to compete commercially with the better developed technologies. Therefore, future CFF development efforts must focus on reducing the cost of catalyst-coated bags, demonstrating a bag and catalyst life of > 2 years, and improving performance with respect to NO_x reduction and ammonia slip at air-to-cloth ratios equivalent to or higher than those used in this evaluation.

5.0 KEY PERSONNEL STAFFING REPORT

Table 1 presents planned versus actual work hours for key EERC personnel involved in the CFF project through March 1994. Work hours reported for Mr. Robie of RE&C represent hours invoiced through March 1994.

TABLE 1

Planned Versus Actual Work Hours
for Key Project Personnel Through March 1994

Key Personnel	Planned Hours	Actual Hours	Percentage of Total Available Work Hours Used
Greg F. Weber	2290	2401	105
Dennis L. Laudal	3380	1238	37
Chris Robie	364	41	11

6.0 REFERENCES

1. Pirsh, E.A. U.S. Patent 4 220 633, Sept. 2, 1980, assigned to Babcock & Wilcox Co.
2. Pirsh, E.A. U.S. Patent 4 309 386, Jan. 5, 1982, assigned to Babcock & Wilcox Co.
3. Doyle, J.B. et al. U.S. Patent 4 793 981, Dec. 27, 1988, assigned to Babcock & Wilcox Co.
4. Weber, G.F. "SO_x/NO_x Control, Low-Rank Coal Research Under the UND/DOE Cooperative Agreement," quarterly technical progress report DOE/FE/60181-1531; EERC publication, Jan. 1984; Section 6.
5. Kalinowski, M.R.; Nishioka, G.M. "Method for Applying Porous Metal Oxide Coatings to Relatively Nonporous Fibrous Substrates," U.S. Patent 4 732 879, March 22, 1988.
6. Weber, G.F.; Laudal, D.L. "SO_x/NO_x Control - CFF for Simultaneous NO_x and Particulate Control," final technical report for the period April 1, 1988, through June 30, 1989; DE-FC21-86MC10637, EERC publication, Aug. 1989.
7. Weber, G.F.; Miller, S.J.; Laudal, D.L. "Flue Gas Cleanup," final technical report for the period July 1, 1989, through June 30, 1990; DE-FC21-86MC10637, EERC publication, Oct. 1990.

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