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Project Summary

Continued Assessment of a High Velocity Fabric Filtration System Used to Control Fly Ash Emissions

John D. McKenna, John M. Ross, Joyce M. Foster, and Rodney A. Gibson

In a full-scale investigation of a modified pulse-jet fabric filtration, performance of a variety of filter media provided technical and economic information under high-velocity conditions (high gas/cloth ratio). The fly ash emission studies demonstrated that woven fiberglass fabrics and felts made from Teflon and Gore-Tex laminate were capable of meeting the State emission code requirements at gas/cloth ratios of 4/1 to 6/1. The economic analysis showed that, in terms of annualized cost, the gas/cloth ratio, initial bag cost, and bag life represents the greatest potentials for cost reduction. Pressure drop reductions can lower operating cost, but they have only a secondary impact on annualized cost. The analysis compares the effects of incremental changes in bag life, gas/cloth ratio, and bag price on total annualized cost.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report summarizes a technical and economical evaluation of the application of high-velocity fabric filtration to coal-fired boiler fly ash control. The evaluation is based on data from a full-scale field industrial boiler/baghouse operation.

Two independent baghouses of similar size were used to control emissions from different boilers burning essentially the same low sulfur bituminuous coal.

Performance screening of a variety of semi-commercial and commercial filter media was performed in an attempt to determine the better techno-economic alternatives and also provide information on the technical feasibility of operating such a system and filter media at higher filtering velocities. The use of fabric filter baghouses to control fly ash emissions from coal-fired boilers became widespread in the late 1970s. Utility gas/cloth ratios (filtering velocity) normally are about 2/1 (ft/min*), while industrial boilers often operate at about 4/1. Operation at 6/1 or greater can significantly reduce both the capital cost and the space requirements; therefore, both the technical feasibility and economic impact were evaluated. (This report is a follow-on to work reported in EPA-600/7-79-094.) Note that the baghouses were initially at the Kerr Finishing plant in Concord, NC; in 1979 these baghouses were moved to a plant in Travelers Rest, SC, after a fire destroyed the plant in Concord.

Filter Media

The filter media used in the baghouses at Kerr included:

(1) Teflon® felt, style 2663, a tetrafluoroethylene (TFE) fluorocarbon;

(2) Gore-Tex® (GT), an expanded Teflon (polytetrafluoroethylene-PTFE) with interfacing air-filled pores;

(3) Globe Albany 22.5 oz/yd² woven glass with Q-78 finish (GA-22.5);
(4) Globe Albany 15 oz/yd² woven glass with Q-78 finish (GA-15);
(5) P&S 26 oz/yd² woven glass with 10 percent Teflon B finish (PS-26);
(6) Nomex felt, a high-temperature-resistant nylon fiber (polyamide); and
(7) Huyck experimental felted glass.

Teflon felt has been used exclusively in Baghouse No. 1 at Kerr. These bags proved to be very durable and able to withstand repeated manual removal and vacuuming. It was not until after about 1-½ years of service did any appreciable failures occur. After 4 years of operation (less about 8 months because of a fire), 85 of 648 bags (13 percent) were replaced. This performance is somewhat remarkable in light of the experimental nature of the program which resulted (by design) in the exposure of these bags to a variety of severe operating conditions.

Baghouse No. 2 was initially outfitted with Gore-Tex PTFE laminate bags. One complete cell (36 bags) was replaced with Huyck experimental glass bags in March 1977; another cell was outfitted with Globe Albany 22.5 oz/yd² woven glass bags in May 1977. Neither of these cells has failed to date.

The Gore-Tex bags, with a replacement rate of 10 percent during the first year's operation, began to fail at an accelerated rate and, in August 1978, were completely replaced with 26 oz/yd² woven glass bags with Teflon B finish. Many of the Gore-Tex failures may be attributed to damage caused by manual cleaning and handling of the bags. The 26 oz bags held up well for the 6 months of operation before the fire. After being in operation at Travelers Rest for about 3 months, many failures occurred. It is believed that the cleaning, handling, and storage of these bags during the move was the primary cause of failure. After the failure of the 26 oz bags, a decision was made to install 15 oz woven glass in combination with mesh cages. While the experience at Kerr indicated better life with heavier weight glass, some commercial success, when mesh cages with 15 oz glass and pulse jets were used, led to the above decision.

The 36 Huyck felted glass bags tested proved to be very durable. These bags were in place for more than 3 years, and visual inspection indicated no failures.

Two other filter media, Nomex felt and 15 oz/yd² woven glass, were tested in Baghouse No. 2 and found to be lacking in endurance for this particular application and set of operating conditions. It appears that the heavier weight woven glass fabric is more durable than the 15 oz/yd² fabric. The Nomex failed in less than 10 days.

In summary, the bag life study indicated that the Teflon felt bags were very durable and 4 years after start-up, 87 percent of the original bags were still in use. The Huyck glass felt bags, while not tested for as long a period, also proved to be very durable; they were in place for over 3 years. Heavier weight (26 oz/yd²) woven glass was more durable than lighter weight (15 oz/yd²) woven glass for this particular application and set of operating conditions. Nomex felt was found to fail rapidly, as had also been observed in the Kerr pilot study. Gore-Tex bags, which had shown 10 percent failure in the first year of operation, failed at an accelerated rate in the second year and were changed out. The bags tested were Gore-Tex laminate on Gore-Tex woven backing. It is expected that the laminate on a different backing, such as a felt, would provide longer life.

Emission Control Evaluations

The tests performed on baghouse inlets and outlets at Kerr consisted of EPA Methods 1-5 (substituting a medium porosity alundum thimble for a heated glass filter in some tests) and particle sizing tests using Andersen and Brink cascade impactors. In addition, some parameters were continuously monitored by recorders in the baghouse facility control room. Only a limited amount of emission data was obtained during this program. The data acquisition program required that the units be operated in a relatively stable mode; unfortunately, shortly after the desired stability was achieved at Concord, the plant was destroyed by fire. Moving the baghouses to Travelers Rest resulted in a repeat of the unstable operation and the need once again to determine the stable operating mode.

For Teflon felt and Gore-Tex, the Method 5 results also indicated that these two filter media met the State compliance requirements. The lowest outlet emission measured, 0.0087 gr/scf, was obtained on Teflon felt when the house was in Concord. The inlet grain loading averaged about 0.5 gr/scf for House No. 1 and about 0.1 gr/scf lower for House No. 2. While the Gore-Tex bags were undamaged, their emission performance was similar to that of the Teflon.

Characterization of the particle size distribution at the outlet of each house showed that each medium (Teflon felt, Globe Albany 22.5 oz/yd² woven glass, and Gore-Tex/Gore-Tex PTFE laminate) emits essentially the same range of particle sizes. All comparisons were made at a G/C ratio of 6/1 afm.

In summary, the emission studies demonstrated that Teflon felt, Gore-Tex laminate on a woven backing, and woven glass are all capable of meeting the State emission code requirements at gas/cloth ratios of 4/1 to 6/1.

Economics

To better direct the development program, an economic study of the impact of various costs was undertaken. Key parameters evaluated included bag cost, pressure drop cost, and gas/cloth ratio. Unlike the earlier economic evaluations of Kerr, where specific bag cost and/or measured pressure drops were used, the current study was done in a generalized manner so that the cost benefit of achieving a yet untested operating mode could be evaluated.

The approach was specific to Kerr in that a fixed gas volume of 70,000 acfm was used. However, the results will provide some general economic insights valid for from half to twice this volume, thus suitable for many industrial boiler applications. The main variables studied and the range covered for each are shown in Table 1.

Table 1. Variables Studied in Economic Evaluation

Variable	*Range*
Pressure Drop, in. H_2O	*3 to 15*
Bag Costs	*$10 to $100*
Interest, %	*5 to 20*
Bag Replacement, %/yr	*25 to 100*
Gas/Cloth Ratio	*2 to 10*

The economic analysis indicated that, in terms of annualized cost, the gas/cloth ratio and bag life represented the greatest potential for cost reduction. Bag cost could also be important if the cost reduction increment is greater than about $1/ft² of cloth. The analysis indicates that, all else being equal, in order for a $50 bag to compete with a $20 bag, it requires four times longer life. Pressure drop reductions (1 in. increments), while reducing operating costs significantly, do not have as large an impact on annualized costs as do bag cost, gas/cloth ratio, or bag life, when considering increments of $10/bag, 1 ft/min, and 1 year, respectively.

Additive Program

The Apollo Chemical Company manufactures an additive called Coaltrol X-1 (hereafter referred to only as Coaltrol), a powdered solid that, according to the manufacturer, neutralizes SO_3 but does not react with SO_2. Tests were performed in cooperation with Apollo in which varying amounts of the Coaltrol additive were injected into the flue gas stream entering Unit 1 but not Unit 2. Samples of ash collected in Unit 1 were analyzed for free acid, reported as milligrams of H_2SO_4 per gram of

ash, during Coaltrol addition, as well as during normal operation without Coaltrol in order to establish the effectiveness of the Coaltrol additive.

During the period of Coaltrol addition, a limited program to evaluate the effects of the Coaltrol additive on fabric swatch aging and metal corrosion was performed. Two different metals and five different filter media were tested.

The results of a short duration study indicated that such injection was effective in reducing pressure drop, metal corrosion, and fabric deterioration. An extended duration program, along with a cost/benefit analysis, would provide valuable additional data.

Conclusions

Filter Media

- Teflon felt is extremely durable and will withstand removal, manual cleaning, and long-term usage (longer than 3 years).
- Woven glass can be used at a 5/1 gas/cloth ratio, but it appears that heavier weights (>20 oz) may be required to obtain long life.
- Gore-Tex PTFE laminate on PTFE woven backing is not structurally durable enough to make it a practical alternative. This does not rule out the possibility that the Gore-Tex laminate may be suitable on some other more durable backing.
- Huyck's felted glass proved to be very durable. The bags tested were not very flexible and therefore were somewhat difficult to install. These bags were made early in the commercial development of this product, and inspection of subsequent material indicated it to be somewhat more flexible.
- Nomex is not suitable for use in this application and will fail in a matter of weeks.
- The Teflon felt, Gore-Tex, and 26 oz woven glass were capable of controlling emissions to the level needed to meet the State code. No emission performance evaluations were possible for the other filter media tested for life.

Additive Injection

- The injection of Coaltrol into the inlet gas stream resulted in significant reduction of free acidity.
- Reduced metal corrosion occurred due to the injection of Coaltrol.
- In some cases, the strength of certain filter media is retained at higher levels due to the injection of Coaltrol.
- Longer term studies should confirm the above.

Conversion Factors

Readers more familiar with the metric system may use the following factors to convert to nonmetric units that were used in this Summary for convenience.

Nonmetric	Multiplied by	Yields Metric
ft	0.305	m
ft^2	0.093	m^2
ft^3	28.317	ℓ
gr	0.0648	g
in.	2.54	cm
oz	28.35	g
yd	0.914	m

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J. McKenna, J. Ross, J. Foster, and R. Gibson are with ETS, Inc., Roanoke, VA 24018-4394.

***Louis S. Hovis** is the EPA Project Officer (see below).*

The complete report, entitled "Continued Assessment of a High-Velocity Fabric Filtration System Used to Control Fly Ash Emissions," (Order No. PB 84-169 598; Cost: $15.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

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U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

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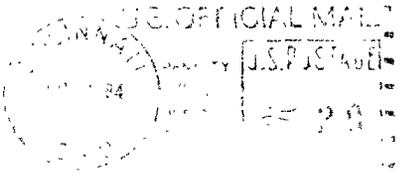

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