Long-term Performance of GORE® Membrane Filter Bags at a Municipal Solid Waste Combustion Facility

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Abstract

This paper describes the performance of particulate emissions control technology used at an 800 ton per day municipal solid waste combustion facility. The technology consists of a pulse jet fabric filter collector equipped with GORE® membrane/ TEFLON® B fiberglass fabric filter bags and a lime slurry spray dryer absorber. During compliance emissions testing in 1995, the air pollution control system processed 110.000 – 121.000 acfm of flue gas delivered through two water wall boiler lines. Total particulate matter emissions averaged 0,003 gr/dscf at 7% O_2 content. Emission levels of low and semi-volatile metals were also measured during the compliance tests. In all cases, these levels were either well below permit levels or below detection limits. Dioxin and furan emissions were measured during the compliance tests and were also found to be below permit levels and applicable federal emission guidelines for municipal waste combustors. This paper presents these emissions data, as well as specific information on the performance of the GORE® membrane filter media including pressure differential, permeability, and strength, over a service life of five years.

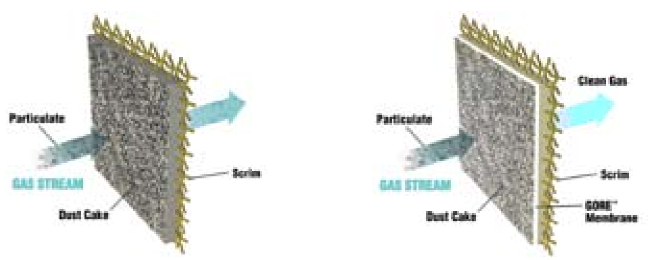
Introduction

The purpose of this paper is to report the latest performance characteristics of the fabric filter collector at a municipal waste-to-energy facility equipped with GORE® membrane filter bags. This facility was designed to generate 26 MW of electricity, and consists of two boiler units rated to dispose of 400 tons per day of municipal waste each. Each unit consists of a water wall boiler that incorporates a thermal deNOx system to control nitrogen oxides. Downstream of each boiler is a spray dryer absorber (SDA) utilizing lime followed by a pulse-jet fabric filter (FF) collector. Each FF uses 1710 GORE® membrane/ TEFLON® B fiber-glass fabric (16,8 oz/yd²) filter bags to control particulate matter (PM). As of November 1996, this facility has been operation for 60 months with the original set of filter bags. In 1995, after 44 months of operation, the facility underwent emissions compliance testing. The emissions data from this testing represents the latest available. This paper presents emissions data related to the control of PM, low and semi-volatile metals, and dioxins/furans, and compares the data with permit emis-sion standards, as well as applicable emission limits under recent Emission Guidelines for Municipal Waste Combustors (MWC) set forth by the U.S. EPA. Although still subject to change, these Emission Guide-lines serve as the latest standards by which MWCs must comply in the near future.

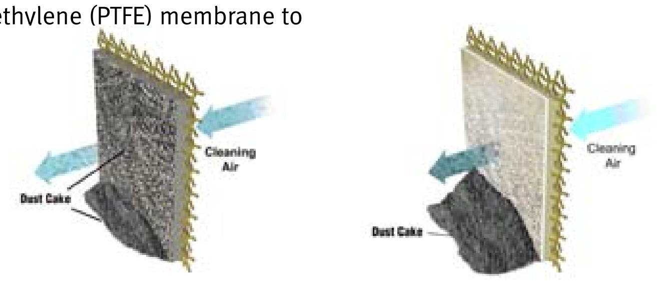
Fabric Filtration Technology

Two primary filtration technologies are currently used in fabric filtration: depth filtration and membrane surface filtration. Depth filtration depends upon a two-stage dust cake development. The primary dust cake is located within the weave of the filter media, and is the first to develop. The secondary dust cake builds upon the primary dust cake. Maintaining the primary dust cake is important because the primary dust cake is responsible for PM capture. The secondary dust cake is responsible for increased static pressure loss, and must be removed by the action of the cleaning cycle. The cleaning action of the fabric filter collector can disturb this primary dust cake and subsequently lead to PM emissions that exceed desired levels. This especially true for submicron PM (below 1 micron in size). GORE® membrane surface filtration, by comparison, uses a microporous, expanded polytetrafluoro-

Depth Filtration | GORE® Membrane Surface Filtration



ethylene (PTFE) membrane to



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collect the PM which impinges upon it. The GORE® membrane, which is laminated to various felt and fabric backing materials, captures even submicron PM without allowing particles to penetrate or pass through the filter media. In other words, PM is collected on the surface of the GORE® membrane, and not within the interstices of the felt or woven fabric. As a result, PM emissions can be consistently maintained at desirable levels.

most signifi-cantly controlled by the fabric filter media. The back-half catch contains the condensable PM extracted from the back to the filter housing to the last impinger of the Method 5 train. Method 202 was used to correct the back-half catch so that ammonia and sulfate compounds were not included. All particulate were assumed to be 10 microns or smaller in size.

Table 1 presents the results of the PM emissions and opacity testing for both units and shows that the emissions levels are well below NOC permit limits and U.S. EPA Emission Guidelines.

Table 1: Average PM Emissions and Opacity Data after 44 Months of Operation

	Unit 1	Unit 2	NOC Permit	PSD Permit	Emission Guidelines
Particulate Matter (gr/dscf @ 7% O_2)					
Total catch	0.003	0.003	0.020	0.020	0.012
Front-half catch	0.001	0.002			
Back-half catch	0.002	0.001			
Opacity (%)	0	0	5	5	10

Emissions Testing

Emissions testing was performed for each unit to demonstrate compliance with the municipality´s Prevention of Significant Deterioration (PSD) permit and the Notice of Construction (NOC) permit issued by the local air pollution control authority. Emissions data reported in this paper were obtained from sampling measurements taken at the FF outlet (i.e., stack).

Total Particulate Matter and Opacity

Total PM emissions and opacity were quantified using EPA Method 5 and Method 9, respectively. The total PM consists of the front-half catch and the back-half catch. The front-half catch includes all PM collected in the sampling train from the nozzle to the filter (including probe wash). It is this fraction that is

Low and Semi-Volatile Metals

Metal emissions were quantified using EPA Method 12. These metals may be carried over from the furnance and entrained in the flue gas as particulate. They can also vaporize and recondense prior to the fabric filter, or vaporize and pass through the fabric filter. Those metal species that recondense can do so either homogeneously, to form new particles, or heterogeneously, on the surface of existing fly ash and reagent particles1. Homogeneous condensation produces metal particulate in the 10 micron and submi-cron size ranges2. Heterogeneous condensation tends to favor submicron particles because of their higher surface area per unit mass.

Table 2 presents the emissions data for the multiple metals for both units and shows that the emission levels are well below

Table 2: Average Low and Semi-Volatile Metals Emissions Data after 44 Months of Operation

Metal Species (µg/dscm @ 7% O_2)	Unit 1	Unit 2	NOC Permit	PSD Permit	Emission Guidelines
Arsenic	0.02	< 0.48 (U)			
Beryllium	‹ 0.10 (U)	< 0.10 (U)			
Cadmium	0.52	0.47			40
Chromium	< 0.48 (U)	< 0.50 (U)			
Nickel	0.66	1.13			
Lead	1.94	2.59	2288	NA	490
Selenium	< 98 (U)	< 97 (U)			
Zinc	13.7	28.6			

U = undetected at the specified detection limit
NA = not applicable

applicable NOC permit and Emission Guideline limits. The values shown in Table 2 represent the sum of the filterable and condensable fractions.

Dioxins and Furans

Emissions of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were quan-tified using EPA Method 23. PCDD/PCDF may condense on particulate matter prior to the fabric filter or pass through the filter as a gas. An increasing number of waste-to-energy facilities are injecting activated carbon upstream of the fabric filter to adsorb gaseous PCDD/PCDF. The pollutant-laden carbon particles are then collected by the filter media. Any unspent sorbent residing on the filter media can also provide additional adsorption of PCDD/PCDF.

Table 3: Average PCDD/PCDF Emissions Data after 44 Months of Operation

	Unit 1	Unit 2	NOC Permit	PSD Permit	Emission Guidelines
2,3,7,8 TCDD TEQ (Using 1989 I-TEF Equivalencies) ng/dscm @ 7% O_2	0.0010	0.0008	4.1	NA	
Total PCDD/PCDF (tetra-octa) ng/dscm @ 7% O_2	0.346	0.180			30

NA = not applicable

The facility described in this paper did not utilize activated carbon injection in conjunction with the com-pliance tests.

Table 3 presents emissions data for PCDD/PCDF for both units and shows that emission levels are well below the NOC permit limit and Emission Guidelines. The data is presented two ways:

(1) as a toxic equivalent (TEQ) value relative to 2,3,7,8 tetrachlorodibenzodioxin (TCDD), and

(2) as the total emission of all PCDD/PCDF compounds (tetra – octa).

The TEQ value is the total amount of 2,3,7,8-TCDD which constitutes the equivalent combined risk of all the individual PCDD/PCDF compounds based on I-TEF equivalencies.

Filter Media Performance

Table 4 summarizes average flow rate and temperature conditions at the outlet of each unit´s fabric filter collector during the emissions testing. The table also includes operational data for each collector. The operational data was collected during a recent visit coinciding with a filter bag service life of over 60 months. For comparison purposes, the pressure differential across the GORE® membrane filter media during the month of July 1992 was maintained at approximately 6-7inches of water gauge (w.g.) while pulsing at 60-65 psig.

Conclusions

After 44 months of operation, the waste-to-energy facility described in this paper was able to maintain emission levels of PM, low and semi-volatile metals, and dioxins/furans well below local air pollution control standards and future federally-mandated Emission Guidelines. Contributing to this degree of pollu-tion control were the GORE® membrane filter bags installed in the facility´s two fabric filter collectors. The permeability and planar strength of these filter bags were tested after approximately 60 months of opera-tion. The results

Table 4: Fabric Filter Operational Data

	Unit 1	Unit 2
Volumetric Flow Rate at Outlet Temperature (afcm)	121,367	109,881
Outlet Temperature (ºF)	270	273
Air-to-Cloth Ratio (cfm/ft^2)	3.35 (Gross) 4.02 (Net)	3.04 (Gross) 3.65 (Net)
Differential Pressure Across Filter Media (inches w.g.)	6.8	7.0
Pulse Pressure (psig)	65 psi	65 psi
Pulse Frequency (minutes)	On Demand	On Demand

show that permeability has remained well above blinding values and that cleanability is good. The retained Mullen burst strength of the filter media indicates that the expected range of service life is 75 to 88 months. This far exceeds the guaranteed life of 36 months. Some attributable factors to the success of the facility´s fabric filter collector are:

(1) superior operation of the boiler and SDA,

(2) infrequent and low pressure pulsing,

(3) no penetration of PM into and beyond the GORE® membrane which can cause fiberglass fiber breakage due to wear of abrasive dust, and

(4) excellent bag-to-cage fit and bag design which minimized flex fatigue of fiberglass fibers against cage wires, while allowing adequate bag movement on the cage for effective cleaning.

References

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Figure 1: Average Mullen Burst Strength versus Service Life for Unit 1

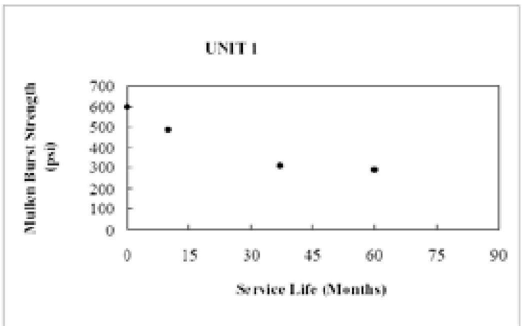

Figure 2: Average Mullen Burst Strength versus Service Life for Unit 2

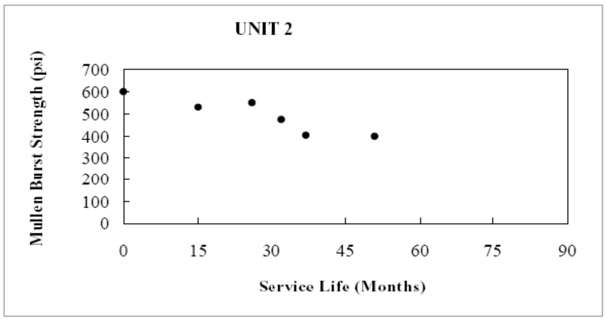

Figure 1 and Figure 2 show the average Mullen burst strength of the filter media versus service life for Unit 1 and Unit 2, respectively. Mullen burst strength is a measure of the two-dimensional, or planar, strength of the filter media, measured in pounds per square inch (psi). Based on fabric filtration theory and experi-ence, the minimum safe level of Mullen burst strength of GORE® membrane / TEFLON® B fiberglass fabric is 120 psi. The data in Figures 1 and 2 suggest that the expected service life of the filter bags is between 75 and 88 months. The guaranteed filter bag life was 36 months.

Figure 3: Average Air Permeability versus Service Life for Unit 1

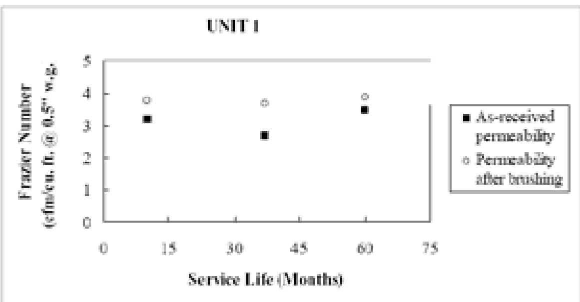

Figure 4: Average Air Permeability versus Service Life for Unit 2

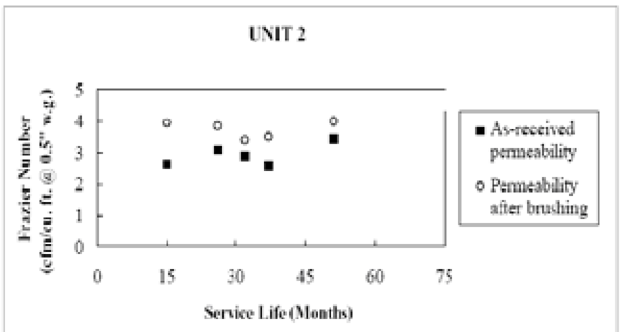

Figure 3 and Figure 4 show the average permeability of the filter media versus service life for Unit 1 and Unit 2, respectively. Permeability is defined here as the volumetric flow rate of air measured in cubic feet per minute (cfm) through a square foot of filter media at a pressure differential of 0.5 inches w.g. The unit of measure is Frazier number (Fn) with units of cfm/ft2 @ 0.5" w.g. As a point of reference, a material with a permeability below 1 Fn is considered blinded. Permeability was measured as-received and after various cleaning steps. The first measurements was taken with as little disturbance of the remaining dust cake as possible. These as-received Frazier numbers indicate that the filter bags are exhibiting good permeability characteristics. The filtration surface was then brushed lightly to simulate an effective cleaning cycle. The increase in permeability after this step, as shown in Figures 3 and 4, indicates that the filter is releasing dust well.