Operating Experience of a Dry Scrubber/Baghouse at the ShuLin Waste-to-Energy Incineration Plant

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Liang Chia Chang
W. L. Gore & Associates (Far East) Ltd. (Taiwan Branch)
4th Floor, No. 136 Section 3, Nanking East Road, Taipei, Taiwan, Republic of China

Keith Fritsky
John R. Darrow
W. L. Gore & Associates, Inc.
1100 Lewisville Road, P.O. Box 1100, Elkton, Maryland 21922-1100, U.S.A.

ABSTRACT

ShuLin Waste-to-Energy Plant is owned by EPB Taipei County, Taiwan, and operated by Ta-Ho Environmental Service Ltd. The facility is designed to handle 1,350 tons per day (TPD) of municipal solid waste. The plant consists of three lines each rated at 450 TPD. Each incinerator uses a Martin moving grate and operates at a temperature of 950°C. The heat is recovered in a boiler and used to generate 24 MW of electricity. The emission control technology consists of a dry lime scrubber and a pulse jet fabric filter collector.

The fabric filter was designed to handle 105,600 Nm^3/hr at a differential pressure of 20 mbar (or less). Within one year of operation, the pressure drop had increased to between 35 to 43 mbar and the gas flow rate was restricted to approximately 93,500 Nm^3/hr. After two years of operation, a decision was made to replace PTFE felt filter bags with expanded PTFE (ePTFE) membrane filter bags to reduce the pressure drop and to achieve the design flow.

The system has been operating for over three years with the ePTFE membrane bags with a lower pressure drop and is now operating at full load. This paper includes comparative data on acid gas and particulate emissions, pressure drop and cleaning frequency, and other data. These improvements represent real and potential operating cost reduction.

Recently, activated carbon injection has been added for control of dioxin. These results are also included in the paper.

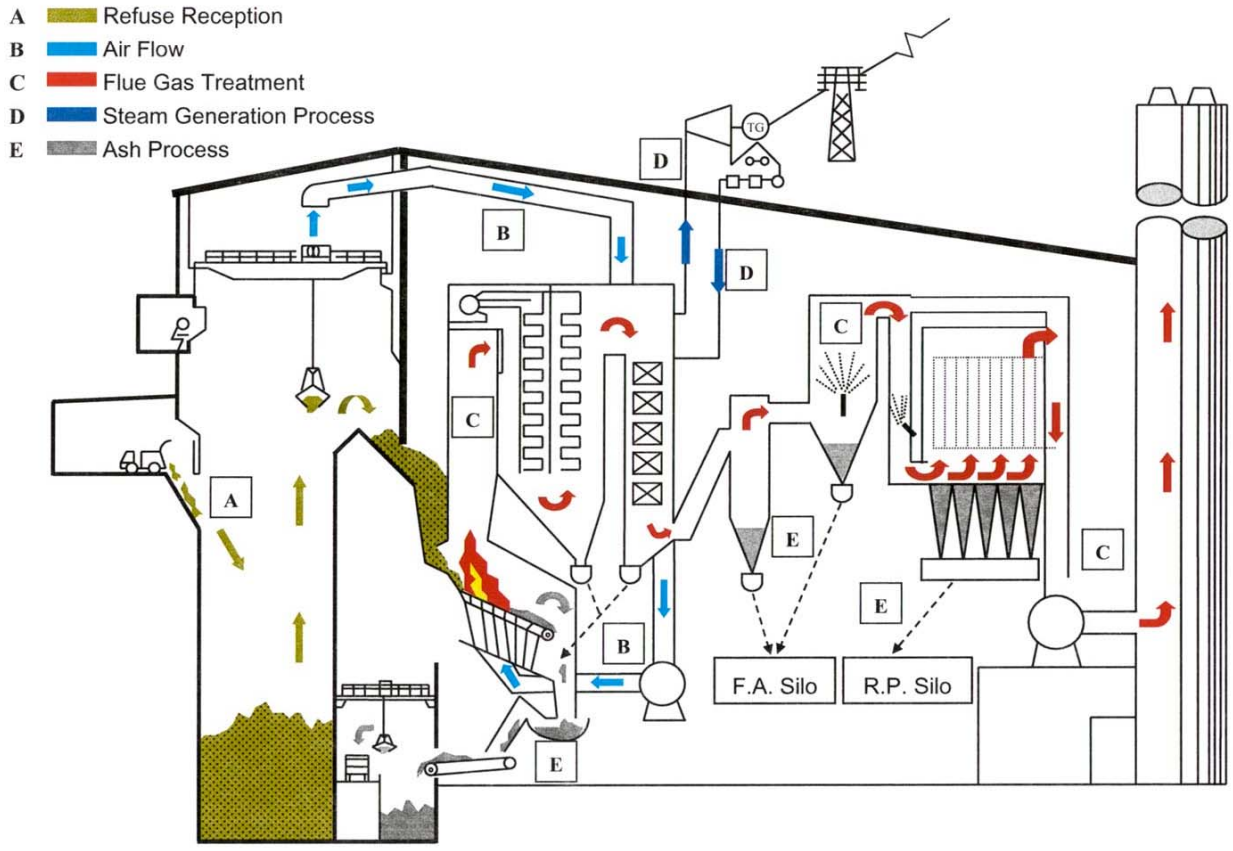
INTRODUCTION

ShuLin Waste-to-Energy Plant is under the jurisdiction of the Taipei County Government Environmental Protection Bureau in Taiwan, Republic of China. The service region of the plant includes the districts of ShuLin, Yingkou, Hsinchuang, Panchiao, Tucheng, and Sanhsia in Taipei County with a population of over 750,000 people. The waste collected and processed is mainly from the capital city of Taipei.

The plant was designed and constructed by Mitsubishi Heavy Industries, Ltd., of Japan (MHI). Initial operation began in July 1995 under MHI. In July of 1996 Ta-Ho Environmental and Technical Services Co., Ltd., took over the commercial operation of the plant under a 6-year contract.

The plant has three incinerators with the daily design processing capacity of each furnace being 450 tons. The furnaces are Mitsubishi–Martin pusher type with patented grate. The operating furnace temperature is controlled at about 950°C. The system is designed to process 18.75 tons per hour of refuse with a heating value of 5,000 to 6,500 kilojoules per kilogram. Heat is recovered in a boiler, superheater and economizer and 39 tons per hour of steam at 400°C and 41 bar pressure is produced. The steam is used to generate 24.8 MW electricity. The plant uses part of the power and the surplus is sold to the Taiwan Power Company. The amount of waste gas to be cleaned is 105,600 Nm^3 per hour for each incinerator line.

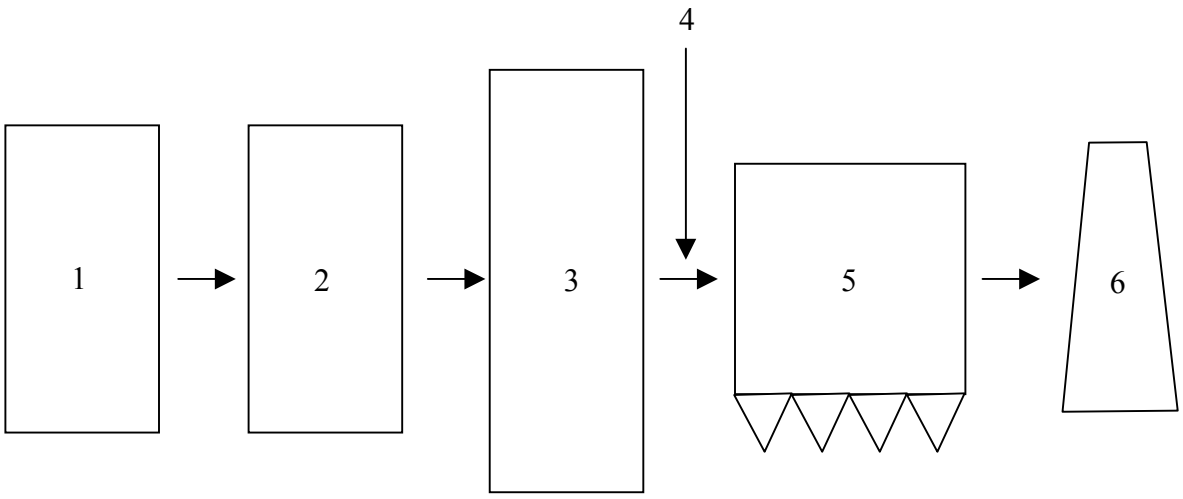
Figure 1. Plant Flow Process



SHULIN WASTE-TO-ENERGY PLANT FLOW PROCESS

The flue gas cleaning system (Figure 2) consists of a cyclone, a spray cooler, a dry injection system, and a fabric filter for each line. Approximately 15 kilograms of hydrated lime are added for each ton of trash burned to control the emissions of hydrogen chloride and sulfur oxides. The reaction products and ash are captured in a fabric filter equipped with polytetrafluroethylene (PTFE) felt bags. Table 1 gives the emissions standards required for the plant and results for PTFE felt bags.

Figure 2. Waste Gas Treatment System



Key to Figure 2

1. Incinerator
2. Cyclone
3. Mist spray cooler
4. Dry injection system
5. Bag-type dust collector
6. Chimney

Table 1. Emission Standards

	Legal Limit	**Actual (Typical)**
Particulate pollutants (dust) – mg/Nm^3	81	Under 10
Sulfur oxides (SOx) – ppm	150	Under 20
Hydrogen chloride (HCl) – ppm	60	30 – 50
Nitrous oxides (NOx) – ppm	220	120 – 166
Carbon monoxide (CO) – ppm	150	Under 20

Each line had a fabric filter made up of eight individual modules containing 132 bags per module. The bag dimensions were 164 mm in diameter by 4,915 mm in length. The total cloth area was 2,674 square meters for each baghouse. Based on the design flow per line of 105,600 Nm^3 at 150°C, the gas-to-cloth ratio was 0.98 m/min (gross) and 1.12 m/min (net) with one module off-line for pulse cleaning.

Early Operation

During the first year of operation, the pressure drop across the fabric filter increased from about 25 mbar to between 35 and 43 mbar. Reaction products sticking to the fibers had blocked the PTFE felt. The filter bags were washed to remove the dust cake. There was a decrease in the pressure drop for a short time. By the second year of operation, the system pressure drop for Line 2 was restricting the gas flow rate to 93,500 Nm^3 (a 12% reduction). Even with frequent pulse cleaning, the fabric filter was effecting the ability of the plant to run at design steam flow capacity.

In June 1997 four compartments of the Line 2 baghouse were replaced with expanded PTFE membrane filter bags that were installed during a brief outage. After the first four compartments were installed, the unit could reach full load. As more compartments were replaced, the Line 2 system pressure drop continued to decrease. A decision was made to replace all 3168 filter bags in the three fabric filters. This work was completed by November 1997.

Operation with Expanded PTFE Membrane Bags

With eight modules of bags in Line 2, the pressure drop had decreased from 43.2 mbar to 15.5 mbar at a flow rate of 117,700 Nm^3. This allowed the chance to reduce the cleaning of the bags. The pulse air pressure was reduced from 5 bar to 3.4 bar. The cleaning cycle time was increased from 27.7 minutes to 117.7 minutes.

Ta-Ho also noticed a decrease in the hydrated lime consumption necessary to meet the HCl control limits. With frequent cleaning to meet the incinerator draft requirements, the lime dust cake on the bag is removed before it has a chance to be fully utilized. Typically, the consumption of hydrated lime was 14 to 16 kg per ton of trash burned. Just before the bag change, the average lime usage was 14.6 kg/ton (24-hr average). After the installation of the PTFE membrane bags, the lime consumption decreased significantly. Because the membrane bags have better cake release, the reaction products are removed with each cleaning cycle. The fresh lime can then remain on the bags longer between cleaning, which results in better utilization. In the three years of operation since the ePTFE membrane bags have been installed, the lime average lime consumption has been 13.8 kg/ton.

In addition to the reduction in hydrated lime usage, the average emission of HCl decreased from approximately 53 ppm to just over 30 ppm. The complete emissions results with the PTFE membrane bags are shown in Table 2.

Table 2. Legal Limits and Actual Emissions Results for ePTFE Membrane Bags

	Legal Limit	Emissions	
Particulate pollutants (dust) – Mg/Nm3	81	5 (w/ePTFE membrane)	
Sulfur oxides (SOx) - ppm	150	4.2	
Hydrogen chloride (HCl) - ppm	60	30.7	
Nitrous oxides (NOx) - ppm	220	Not reported	
Carbon monoxide (CO) - ppm	150	Not reported	

Dioxin Emissions

The ShuLin plant was constructed before there were any regulations controlling dioxin emissions. Levels of 2.8 ng/Nm^3 @ 10% O_2 were measured. After start up, the Environmental Protection Administration of the Executive Yuan announced a dioxin control and emission standard of less than 0.1 ng/Nm^3. To achieve the new dioxin control and emission standards the plant began using activated carbon injection technology in February of 1997. According to an actual measurement on May 23, 2000, dioxin was being held at less than 0.05 ng/Nm^3 @ 10% O_2. The carbon injection rate has been within the expected range for the system.

Summary of Experience with Expanded PTFE Membrane Bags

The GORE-TEX® membrane/SUPERFLEX® filter bags were installed in June of 1997. To date, they are still providing extremely good performance, with average system pressure losses of approximately 25 mbar. They are pulsed 10-12 times every 24 hours, with the induced draft fan damper opened about 40%.

During the first 24,000 hours of operation, there were two incidents where the pressure drop reached 30 mbar across the baghouse system as follows:

1. After the Chinese New Year in the traditional lunar calendar, the system pressure losses rose. It is believed that an increase in water and plastic content in the waste created excessively high water content in the flue gas. The pressure drop was restored to less than 25 mbar after adjusting the pulse cleaning mechanisms.

2. During the annual outage in 1999, the pulse valves were replaced and leaks in the compressed air system were corrected.

See Figure 3 below.

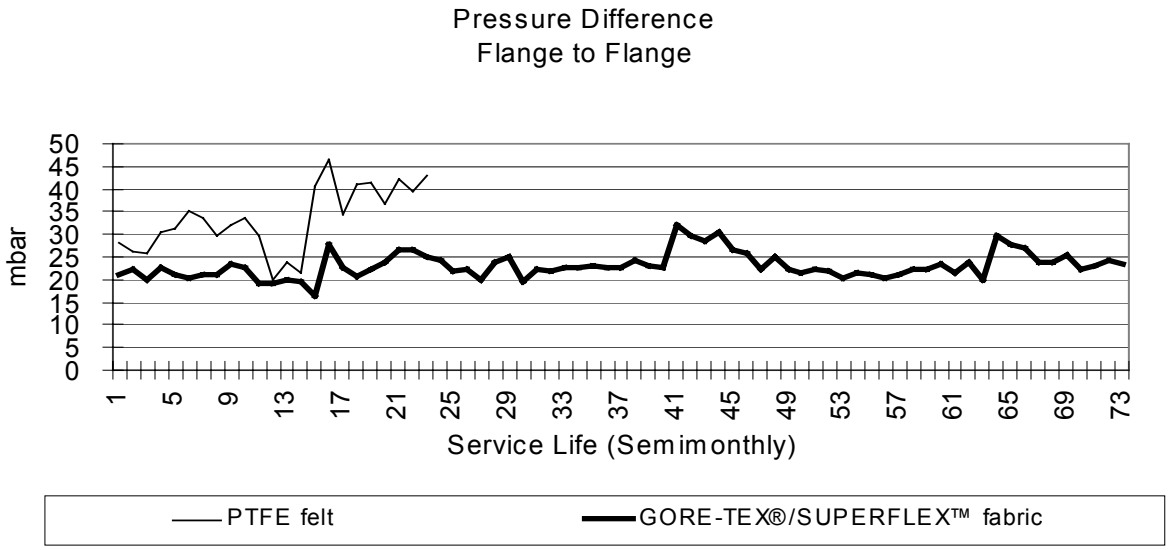
Filter Bag Life Performance

Because the membrane filter bags are important to the system performance, used filter bags are periodically removed for analysis. Based on analyses of bags removed in November 1999 and

December 2000, the bags have over 50% of their relative mechanical strength (Mullen Burst). It is expected that the bags will continue to successfully operate for at least one more year.

Since membrane filter bags can represent a significant investment, the bag life often is a large part in the benefit/cost analysis. The actual life achieved with the PTFE felt filer bags was two years. With the current projected bag life of four years or more, there will be a reduction in bag replacement cost.

Figure 3. Pressure Difference Flange to Flange



Cost Benefits with EPTFE Membrane

Although the actual savings in operating expenses in considered proprietary, it is possible to estimate changes in them on a percent basis. Using the OAQPS Control Cost Manual as a guide, several direct annual cost categories were compared:

1. The reduction in air pressure and the increase in the cycle time represent over a 76% saving in compressed air consumption.
2. The saving in reagent (operating materials) has been approximately 5.5%.
3. The unit costs for the PFTE felt and ePTFE membrane bags were approximately the same. At twice the projected bag life, the ePTFE bags represent a 50% reduction in bag replacement cost (without considering labor).
4. The flange-to-flange pressure drop has been 30% lower with the ePTFE bags. In theory, this would account for a 30% reduction in fan horsepower. Since the fan speed is fixed, there has been no saving in fan energy required.

There has been another operational benefit. With the PTFE felt bags, the fan damper was 100% open. This resulted in limited steam production at times when the heating value of the trash was low. The lost production had been as much as 10,000 kg/hr. With the ePTFE membrane bags, the fan damper is normally 40% open. This allows better control of the combustion process. The steam flow has been consistently at 39 tons/hr and at times been as high as 40.5 tons/hr.

CONCLUSIONS

From the time that ShuLin Waste-to-Energy Plant began using ePTFE membrane filter bags until now, operations have proceeded smoothly. All of the data indicate that they are superior to using PTFE felt filter bags and all emissions are below legal stipulations.

- Particulate pollutants (PM) were under 5 mg/Nm^3 @ 10% O_2.
- Dioxin was under the emission limit of 0.1 ng/Nm^3 @ 10% O_2.
- Acidic gases HCl < 30.7 ppm, SOx < 4.2 ppm, HF < at 1 mg @ 10% O_2.

To date, ePTFE membrane filter bags have provided excellent performance with an average system pressure loss of 25 mbar and pulsing 10-12 times every 24 hours. The induced draft fans are operating at about 40% damper opening, which permits excellent control of the incinerator. After more than 24,000 hours of operation, the bags have excellent retained strength. It is expected that the performance will continue for a year or more.

Therefore, whether it is from the perspective of environmental protection or economics, the operational performance of ePTFE membrane filter bags at the ShuLin Waste-to-Energy Plant to date has been satisfactory and successful.

ACKNOWLEDGMENTS

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KEY WORDS

Baghouse
Fabric
Filter
Incinerator
Emissions