Dust Emission Control Filter Elements for Hot Gas Filtration

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INTRODUCTION

Filtration is one of the methods used to control dust emission pollution in many industries. There are many types of filtration techniques available from simple to more complicated filtration systems. Fabric type filtration houses a number of fabric bags placed in a single or multiple compartments as depicted in *Figure 1*. This system is known as the most efficient dust emission control with removal efficiency of 99.9+%. It can handle acid mist, organics and metallic compounds in a single unit with the support of flue gas cleaning agents.

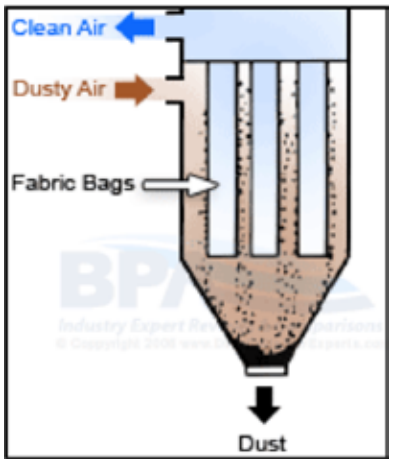

Figure 1. Basic principles of filtration for dust emission control.

However, fabric type filtration unit has a main disadvantage of not being able to operate in high temperature environment as fabric is not able to withstand and perform its function as a filtering device in high temperature. Alternatively, a more robust type of filters such as hot gas filter, which is ceramic or ceramic like filter candle, is becoming popular and relevant to be considered where fabric type filter fails. Hot gas filters element has been developed over the years with improvements in filtration characteristic along with its mechanical strength, thermal shock and chemical resistance properties. These are among the most important parameters to consider when dealing with dust emission control applications in high temperature environment. Some of the applications of hot gas filters are:

- Biomass boiler,
- Incineration of industrial and chemical waste,
- Incineration of clinical, animal and domestic waste,
- Waste to energy plant,
- Wood waste burning,
- Crematorium incinerator,
- Soil remediation and reclamation,
- Metallurgical processing,
- Precious metal recovery,
- Furnaces, *etc*.

ENVIRO-FILTRATION HOT GAS FILTER

Enviro-Filtration (EF) hot gas filter elements are manufactured by TENMAT Advance Materials, United Kingdom. The bio-soluble material and inorganic bonds enabled them to be used at temperature up to 1000°C. These filter elements are designed to remove particulate emission from hot gases offering higher removal efficiency compared to any other conventional filtration system. Other chemical pollutants such as acid gases, metals and dioxin-furan can be removed with the use of flue gas cleaning agent or sorbents.

The filter elements are capable to capture particles less than one micron in diameter where additional filtration is provided by the formation of the dust cake layer deposited on the filter element. The resultant emission levels are typically lower than 10 mg m^{-3}. These hot gas filter elements are proven to offer cleaner emission

compared to electrostatic precipitators or wet scrubbers. Interestingly, the filter elements are self-supporting and do not require metal cages as in typical fabric, thus saving installation time. This is also of value in corrosive flue gas environments. Some of the key features of the hot gas filter elements are:

- Resistance in excess of 1000°C,
- 99.99+% filtration efficiency,
- 100% spark proof,
- Self-supporting,
- High strength, and
- High chemical resistance.

The EF hot gas filter elements are available in two different sizes, 60 and 150 mm in diameter. The smaller diameter consists of 1000, 1250, and 1500 mm in length while the bigger diameter has three different lengths to offer, *i.e.* 1800, 2400, and 3000 mm (*Table 1*).

The EF hot gas filter elements provide the flexibility of providing options to customers based on their specific requirements and limitations. A simple schematic diagram of the hot gas filtration system is shown in *Figure 2*, while the actual bottom view of the filter elements arrangement in the compartment can be seen in *Figure 3.*

TABLE 1. AVAILABILITY OF ENVIRO-FILTRATION HOT GAS FILTER ELEMENTS

	CS1150F			CS1255F		
External diameter (mm)	60	60	60	150	150	150
Internal diameter (mm)	40	40	40	110	110	110
Length (mm)	1000	1250	1500	1800	2400	3000
Flange diameter (mm)	80	80	80	190	190	190
Surface area (m^2)	0.19	0.23	0.28	0.83	1.11	1.40

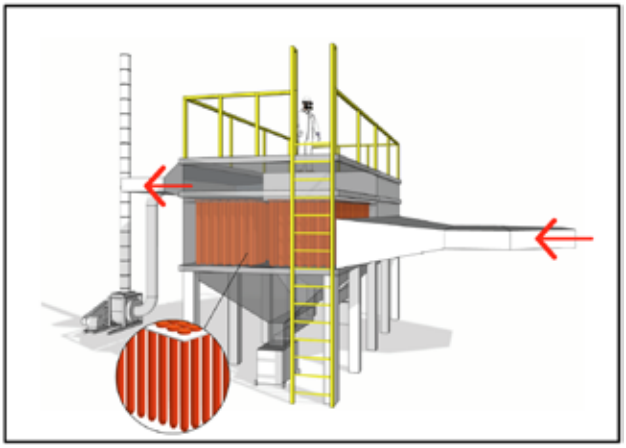

Figure 2. A simple schematic diagram of Enviro-Filtration (EF) hot gas filtration system.

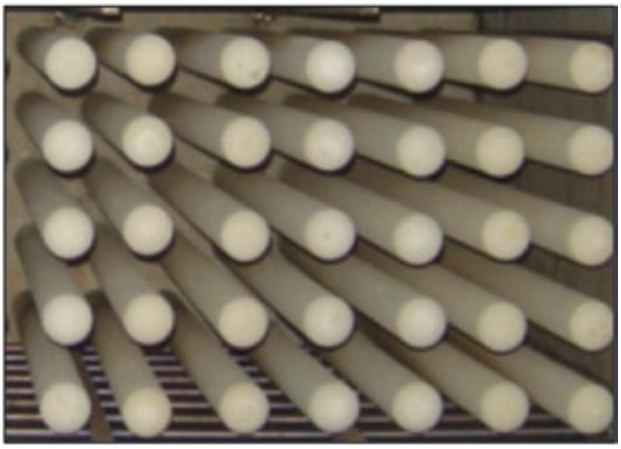

Figure 3. Bottom view of the Enviro-Filtration (EF) hot gas filter elements in a filtration compartment.

Benefits of hot gas filter elements:

- Would not tear,
- Emission level well below 10 mg m^{-3},
- No need for gas cooling,
- No need for metal cages,
- Reduce energy consumption,
- Protects vital components,
- Non-ceramic,
- Less maintenance, and
- Small footprint.

THE PERFORMANCE TEST

The pilot plant

The performance of the EF hot gas filter was tested in the pilot plant scale filtration system of the Air Resources Research Laboratory (Malaysia), Japan International Institute of Technology and Universiti Teknologi Malaysia (*Figure 4*). The filtration system comprises four cylindrical shape filter elements (40 mm x 60 mm x 1500 mm litre), a dust hopper, dust feeder, pulse-jet compressed air and pressure gauge. The unit is equipped with control panel, an induced draft ID fan and a stack.

Figure 4. Air Resources Research Laboratory Filtration Pilot Plant.

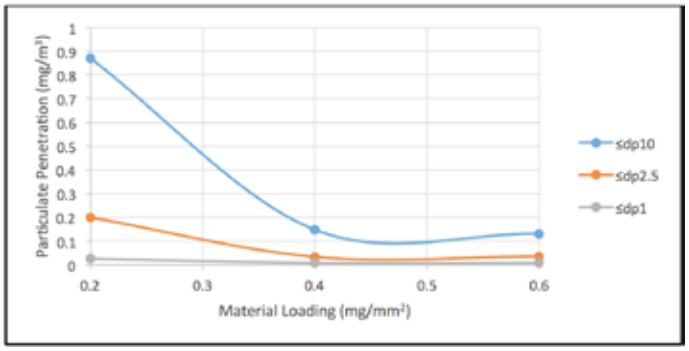

Figure 5. Particulate penetration against various inlet mass loading with high filtering velocity of 18 cm s^{-1}.

The experiment

The performance of the filter elements was measured in terms of particulate penetration, *i.e.* concentration of particulate mass able to pass through the filter element. A flue gas cleaning agent, TrikotAC powder, was used as test sample in the experiment. Different particulate mass loadings of 0.2, 0.4 and 0.6 mg mm^{-2} of the sample were subjected to high filtering velocity of 18 cm s^{-1}, in order to test the performance of these filter elements under extreme condition. However, in actual industrial applications, the filtering velocity is set between 1 cm s^{-1} and 3 cm s^{-1}. The particulate penetration was determined at the stack of the pilot plant by GRIMM Aerosol Portable Laser Aerosol Spectrometer, which is able to detect particulate diameter ranging from 0.3 mm to 32 mm in size.

Results

Figure 5 presents the results of the performance test on the EF hot gas filter element which showed that the particulate penetration of particulate diameter less or equal to 10 µm ($dp \leq 10$) along with its size fraction of 2.5 µm ($dp \leq 2.5$) and 1.0 µm ($dp \leq 1.0$) were significantly lower than 1.0 mg m^{-3}. Note that both $dp \leq 2.5$ µm and $dp \leq 1.0$ µm constitute part of the $dp \leq 10$ µm particulate size fraction in this case. This finding simply suggests that the efficiency of the hot gas filtration on the removal of dust emission will be extremely high knowing that low filtering velocity will be used in actual industrial application.

As expected, the performance of the filter element increases with particulate mass loading. This is because the formation of dust cake layer deposited on the surface of the filter element helped to provide additional barrier for removal. This is one of the unique features of filtration system in comparison to other emission control devices, whereby increased in inlet mass loading increases its collection efficiency even for very fine particulate size fraction. Evidently, as observed in this study, the hot gas filter element is capable of capturing particles of less than 1.0 µm in diameter due to this effect.

CONCLUSION

Filtration is known to be one of the most efficient techniques for emission control that is applicable to many industries. The advancement of hot gas filter element will further extend a wide range applications of such technology. In addition to high removal efficiency, the hot gas filter offered an unprecedented temperature and chemical resistance with long term durability.