Proof of Success

Chris Polizzi, W.L. Gore & Associates Inc., USA, explains the US EPA ETV programme, a verification procedure that makes filter selection easier for cement plants.

Figure 1. Cross-section of conventional non-membrane fibreglass fabric.

Introduction

Cement kiln operators are challenged by both regulatory pressures to keep particulate matter (PM) emissions to the lowest possible levels, and by capital and operating needs in order to stay competitive. These demands have caused more emphasis to be placed on the optimisation of air pollution control systems in general and specifically on pulse-jet baghouses increasingly being used on cement kilns.

Since filter media (membrane or non-membrane) is the key component of these dust collectors, many suppliers and materials are now available. This has resulted in a wide variety of choices, and often confusion as to which media is best for a given application. The challenge is to find a baghouse filter media that is highly efficient, able to handle high airflow rates with low operating differential pressure, and provides the longest possible performance. To facilitate evaluation of the numerous available filter media and provide an unbiased resource for the industry, the United States Environmental Protection Agency has instituted the Environmental Technology Verification programme (US EPA ETV programme). This programme is designed to advance the introduction of viable technologies that will help cement producers meet their productivity and emissions targets, whilst also supporting the cleaner air goals promoted by the EPA.

Background

Over the past ten years, a significant movement has been made towards using pulse jet baghouses to control particulate matter emissions from cement kilns. The massive increase in the number of these systems added to cement kilns in this period has been in part fuelled by more stringent legislation. This, coupled with design and construction advances of pulse jet baghouses and the introduction of advanced filter materials, has resulted in a notable increase in overall system performance. A significant part of this performance increase is due to the growing use of cleanable surface filtration technology provided by expanded polytetrafluoroethylene (ePTFE) membrane filters.

This trend is expected to continue as global regulatory requirements continue to become stricter with respect to total PM emissions as well as fine particulate matter in both the < 10 µm and < 2.5 µm ranges (PM10 and PM2.5). This will make media selection an even more critical decision.

Before discussing the new US EPA ETV programme, a quick overview of the two broad types of technologies available for fabric filtration is appropriate. They are depth filtration, often referred to as conventional filters, and membrane filtration often referred to as surface filters.

Depth (conventional) filtration

Depth filters function on the principle of a two stage dust cake. The first is a primary dust cake, which is located within the interstices or cross-section of the felted or woven fabric (Figure 1). This helps the media become more efficient than it would be naturally. The secondary dust cake builds upon the surface of this primary dust cake. The primary dust cake is necessary and responsible for the capture of particulate matter (PM) and consequently for maintaining PM emissions. The secondary dust cake is responsible for increased static pressure losses (differential pressure

Table 1. Technologies tested to date using ETV programme			
Supplier	**Type**	**Product description**	**Verification date**
Air Purator Corporation	Membrane	PTFE film applied to a 22 opsy glass felt	September 2000
Albany International Corporation	Conventional	16 opsy polyethylene terephthalate	September 2000
BASF Corporation	Conventional	14 opsy Basofil	September 2000
BHA Group Inc.	Membrane	Woven-glass-base fabric with an expanded microporous PTFE membrane, thermally laminated to the filtration/dust cake surface	September 2000
BHA Group Inc.	Membrane	Polyester needlefelt substrate with an expanded, microporous PTFE membrane, thermally laminated to the filtration/ dust-cake surface	September 2001
BWF America Inc.	Conventional	18 – 20 opsy (0.61 – 0.68 kg/m^2) micro-pore size, high efficiency, scrim-supported felt, singed cake side	September 2000
BWF America Inc.	Conventional	18 – 20 opsy (0.61 – 0.68 kg/m^2) micro-pore size, high efficiency, scrim-supported felt, singed cake side	July 2002
Inspec Fibres	Conventional	16 opsy 100% scrim supported P84 needlefelt	September 2000
Menardi-Criswell	Conventional	16 opsy singed microdenier polyester felt	September 2000
Polymer Group Inc.	Conventional	Non-scim-supported, 10 opsy, 100% polyester, non-woven fabric	September 2001
Standard Filter Corp.	Conventional	Stratified microdenier polyester non-woven filter media for use in fine particulate capture	September 2000
Tertratec PTFE Technologies	Membrane	16 opsy polyester needlefelt with Tetratex® expanded polytetrafluoroethylene (PTFE) membrane	September 2001
Tetratec PTFE Technologies	Membrane	16 opsy polyester scrim-supported needlefelt with a Tetratex® expanded PTFE membrane	September 2000
W.L. Gore & Associates Inc.	Membrane	GORE-TEX® ePTFE membrane/polyester felt laminate	September 2000
W.L. Gore & Associates Inc.	Membrane	GORE-TEX® ePTFE membrane/polyester felt laminate	September 2001
W.L. Gore & Associates Inc.	Membrane	GORE-TEX® membrane/fibregalss fabric laminate with a weight of 22 opsy (746 gpsm) - Pristyne® expanded PTFE membrane on woven PTFE coated fibreglass (746 g/m^2 22 oz/yd^2) - product code 6250	August 2006

across the filter media). In order to maintain a static pressure loss that is acceptable, the secondary dust cake must be removed on a periodic basis. Excessive cleaning required to remove the secondary dust cake disturbs the primary dust cake and has the potential to lead to emissions spikes and degradation of the fibres or yarns within the felt or woven media. This is caused primarily through fibre-to-fibre and fibre-to-dust abrasion.

Surface (membrane) filtration

In 1975 W. L. Gore & Associates, Inc. (Gore) introduced GORE-TEX® membrane filter bags bringing a new concept to the industrial filtration field–membrane surface filtration. Membrane filtration utilises an ePTFE membrane that is laminated to a specific backing material chosen to be compatible with the mechanical, thermal, and chemical requirements of the system (Figure 2). This membrane is a microporous structure made up of nodes and fibrils in various orientations and results in a highly efficient structure without the need for a primary dust cake (Figure 3).

The membrane itself is chemically inert, operational to 260 °C with surges to 285 °C, and non-stick. The dust collected on the membrane is kept near the filter surface, where it is almost completely dislodged with each cleaning cycle. This "surface filtration" and very high efficiency membrane allow these filters to operate at higher filtration velocities (air-to-cloth ratios), with lower filter resistances, and with the best filtration efficiencies available to the industrial market. In addition to these unique properties of surface filtration, careful filter bag design, special materials of construction, quality manufacturing and field optimisation of the baghouse

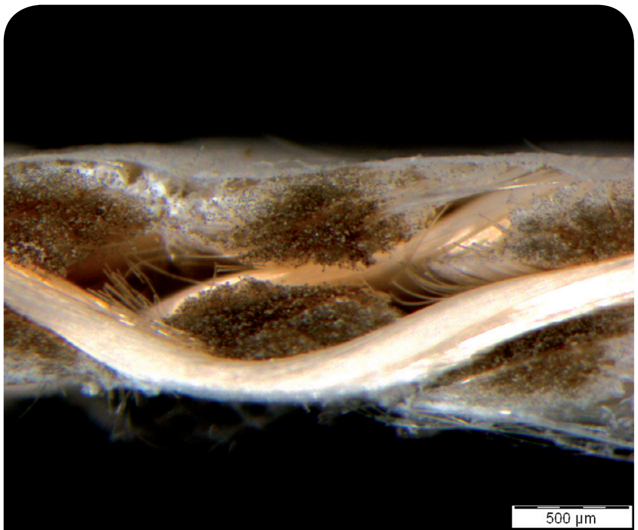

Figure 2. Cross-section of GORE™ membrane laminated to woven fibreglass fabric.

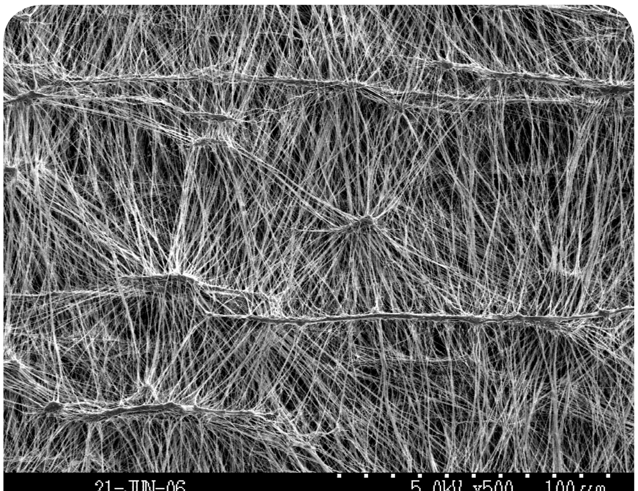

Figure 3. 500 x SEM of new generation GORE™ ePTFE membrane.

cleaning system, membrane filters last much longer than conventional filter media.

Choices of filter media

Although there are some cement kiln pulse baghouses using depth (conventional) filters such as acrylic felts or polyimide felts, the majority of the cement kiln pulse baghouses currently in use globally employ ePTFE membrane filters with fibreglass as a substrate. In addition to the filter media itself, there are many other factors in selecting the optimal filter media for a cement kiln baghouse: the design and manufacturing criteria of the filter bags, the knowledge and applications capability of the filter media supplier, the supplier's performance guarantees for the filter media, the reputation of the supplier, and experience within the cement industry. To eliminate promotional bias in the critical area of media selection, the US Environmental Protection Agency has developed a programme that independently tests various filter media for critical performance characteristics. The programme is the Baghouse Filtration Products Environmental Technology Verification Programme (ETV).

ETV programme

The ETV programme was developed with the goal of providing credible performance data to vendors, end-users, permit writers and the public on commercially available environmental technologies. It provides a forum in a laboratory environment to evaluate filter media for performance characteristics important to end-users. The test protocols were developed and agreed upon by a baghouse filtration product technical panel, which included a group of filter media suppliers and manufacturers, end-users, the testing laboratory and the ETV programme administrators and regulators. Vendors can submit commercial technologies on a voluntary basis to be tested within the programme.

Suppliers who voluntarily elect to submit a technology for verification must randomly select filter samples from

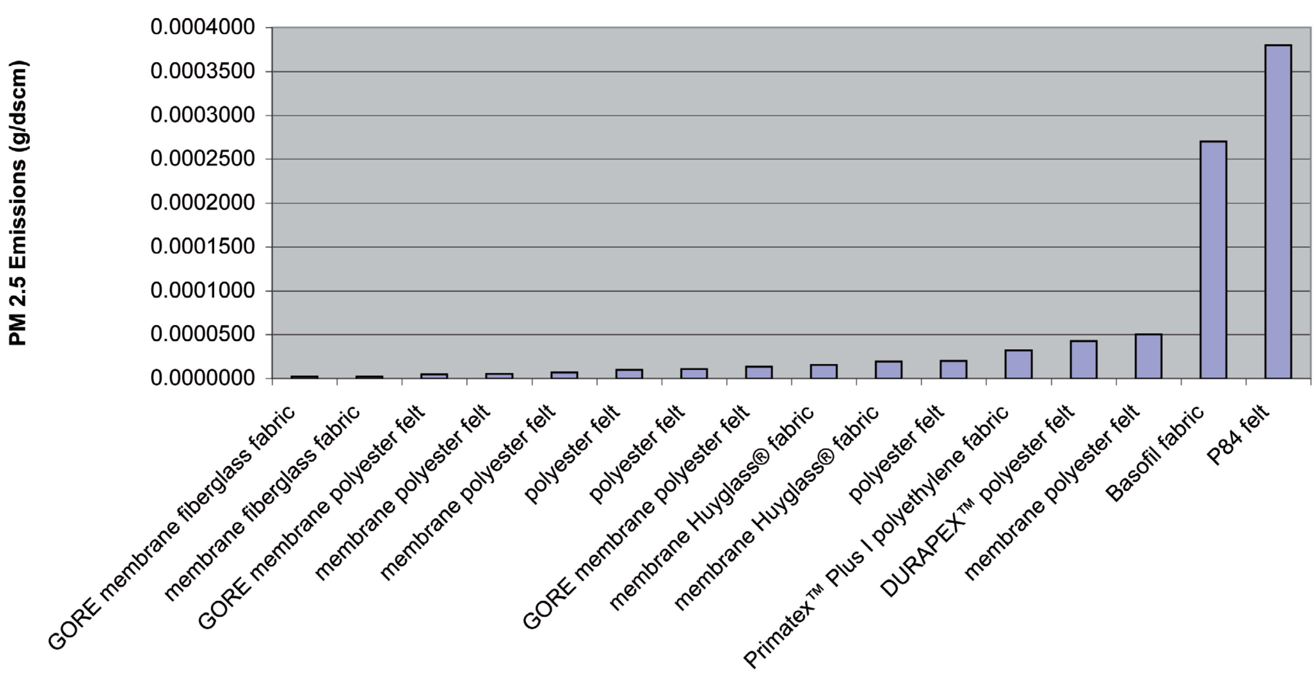

Figure 4. ETV performance data: emissions PM 2.5.

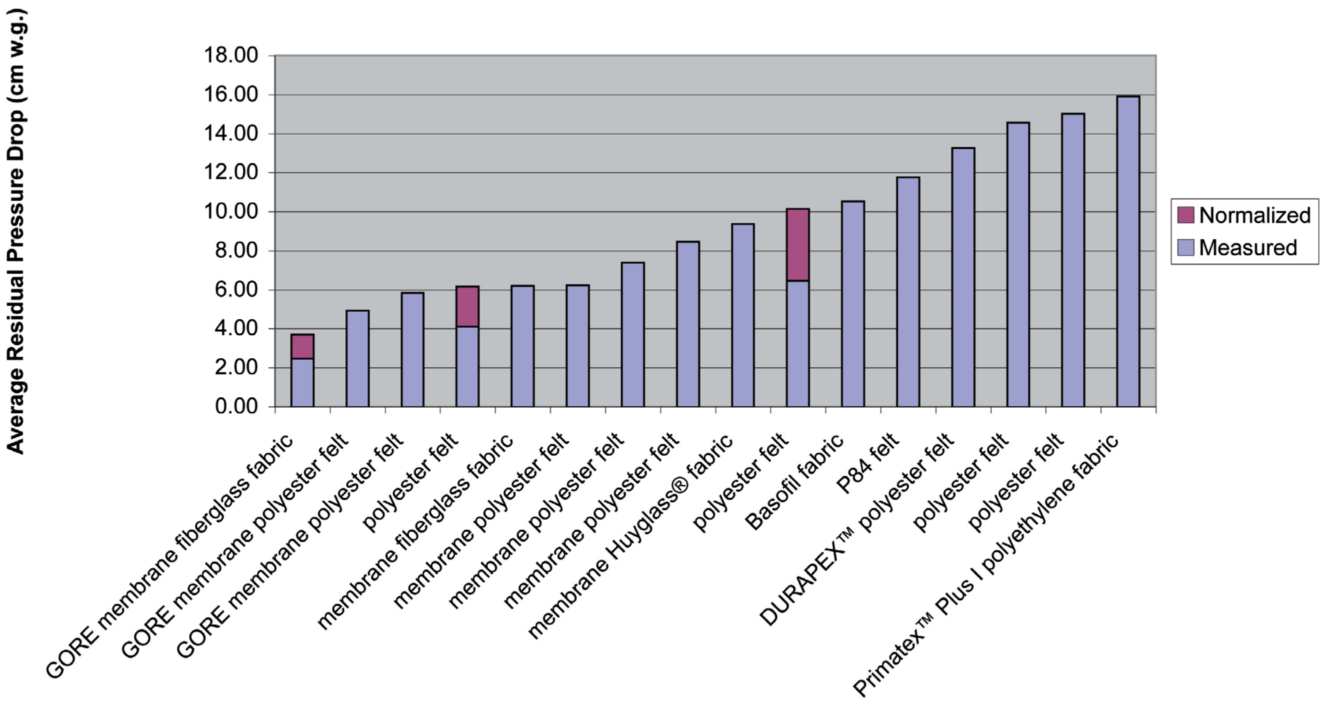

Figure 5. ETV performance data: pressure drop.

Table 2. Filtration velocity conditions before and after modification

	Original protocol	Revised protocol
Dust concentration	18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf)	18.4 ± 3.6 g/dscm (8.0 ± 1.6 gr/dscf)
Filtration velocity (G/C)	180 ± 9 m/h (9.8 ± 0.5 fpm)	120 ± 6 m/h (6.6 ± 0.3 fpm)
Pressure loss before cleaning	1000 ± 12 Pa (4 ± 0.05 in. w.g.)	1000 ± 12 Pa (4 ± 0.05 in. w.g.)
Tank pressure	0.52 ± 0.03 Mpa (75 ± 5 psi)	0.5 ± 0.3 Mpa (75 ± 5 psi)
Valve opening time	50 ± 5 ms	50 ± 5 ms
Air temperature	25 ± 2 ˚C (77 ± 4˚F)	25 ± 2 ˚C (77 ± 4˚F)
Relative humidity	50 ± 10 %	50 ± 10 %
Raw gas stream flow rate	5.8 m^3/h (3.4 cfm)	5.8 m^3/h (3.4 cfm)
Sample gas stream flow rate	1.13 m^3/h (0.67 cfm)	1.13 m^3/h (0.67 cfm)
Number of filtration cycles		
During conditioning period	10 000 cycles	10 000 cycles
During recovery period	30 cycles	30 cycles
Performance test duration	6 hours	6 hours

manufacturing runs of commercially available materials. In independent ETV test laboratories, these samples are subjected to a conditioning period of 10 000 rapid pulse cleaning cycles. Following the conditioning period is a recovery period of 30 normal filtration cycles. The actual 6-hour performance test then takes place. During the conditioning period, the recovery period and the 6-hour performance test, conditions are monitored to provide constant operating conditions based on agreed upon protocols (Table 2).

While subjecting filter media to constant airflow, humidity and dust loading, the filtration media is evaluated by measuring total outlet particulate matter (PM) emissions and particulate emissions smaller than 2.5 µm (PM2.5), residual differential pressure, cleaning frequency and the total number of cleaning cycles during the test. The test results are formally reported in a verification document and posted on the ETV programme website for public access.[1]

To date, the ETV air pollution control technology centre has verified the performance of 17 filter media technologies. The technologies are split roughly equally between depth (conventional) filter media and ePTFE membrane (surface) filter media. Table 1 shows the list of all technologies tested to date.

At the request of industry experts, filtration velocity conditions were modified in 2002 to better reflect actual operating conditions. The protocols are shown in Table 2. To date, three technologies have been tested using the updated protocols and Gore's membrane/fibreglass fabric laminate material with a weight of 22 oz/yd^2 (746/g/m^2) is the only laminate that has been verified under the new protocols. Performance results in key parameters of total PM, PM2.5, residual differential pressure and total number of cleaning cycles are shown in Figures 4, 5, and 6. The data has been normalised to compare the different protocols. On average, ePTFE membrane filters significantly outperformed non-membrane depth filters.

The total outlet PM emissions and particulate emissions smaller than 2.5 µm (PM2.5) results from the ETV test can provide confidence to a user in a material's ability to be highly efficient and meet the outlet emission requirements of the plant. Figure 4 shows the PM2.5 emissions results of all the technologies tested to date.

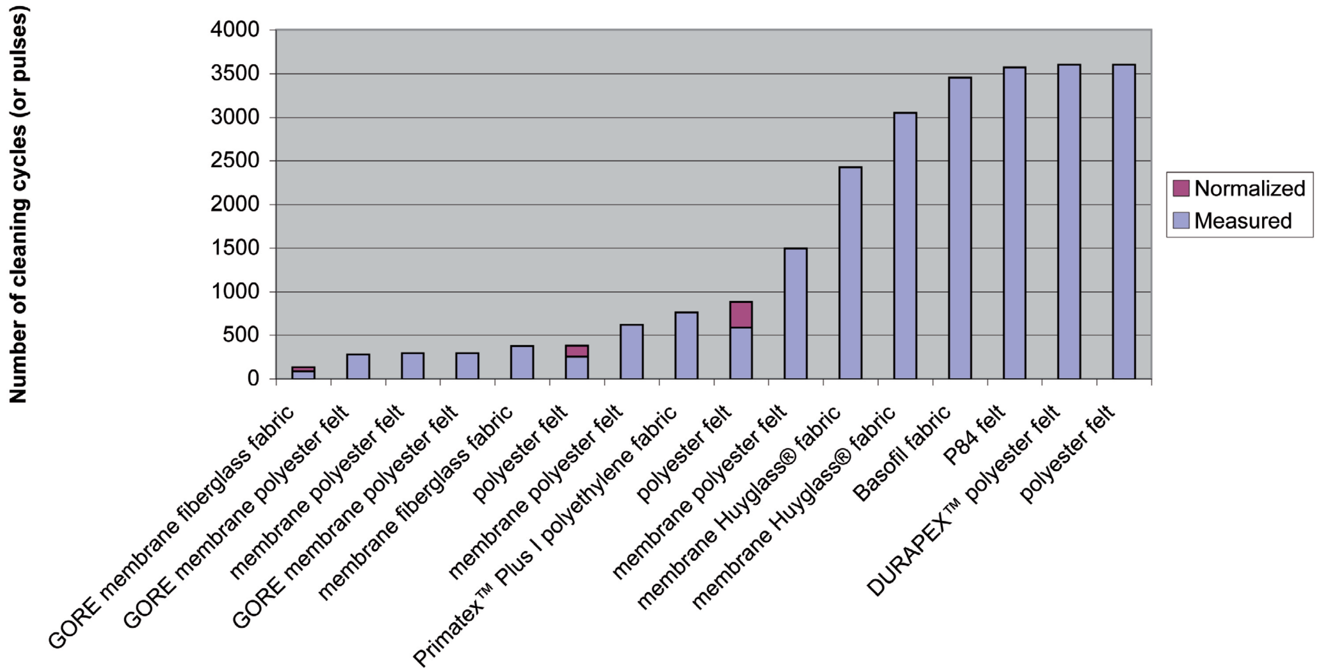

Figure 6. ETV performance data: cleaning cycles.

The residual differential pressure results from the ETV test indicate the ability of a media to handle high airflow rates with low operating differential. Figure 5 shows the differential pressure (pressure drop) results of all the technologies tested to date.

The total number of cleaning cycles results from the ETV test indicate the cleanability of the filter media and ability to provide the longest possible performance or filter bag life. Figure 6 shows the total number of cleaning cycles of all the technologies tested to date.

The United States EPA's Environmental Technology Verification programme provides baghouse users an un-biased data testing programme, which is a useful tool in the search for baghouse filter media that fulfills all the necessary criteria.

References

1. ETV programme website: http://www.epa.gov/etv/verifications/vcenter5-2.html