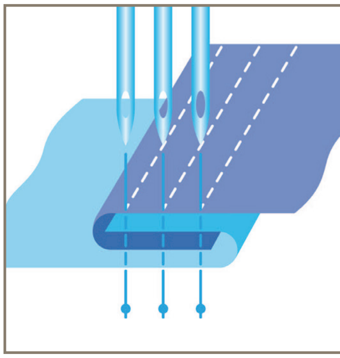
In Search of The Magic Filter Bag

A solution for cement, making particulate emissions challenges a thing of the past



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Introduction

Almost every cement plant in the US is evaluating how it will comply with proposed National Emission Standards for Hazardous Air Pollutants (NESHAP) Particulate Matter (PM) limits. Although the NESHAP limits are particular to the US, filtration technology trends and best practices can have an impact on producers globally. Even before the requirements and implementation timings are settled, meeting new limits led to dreams of a 'magic filter bag' – a special solution that could make even the toughest particulate emissions challenges a thing of the past.

Reality check

The truth is that there is no sorcery to be discovered, but there are practical lessons to be remembered.

A filter bag is only one of many components in a dust collector. The mechanics of basic dust removal technology are decidedly simple: particulate removal efficiency is a function of the effective and collective operation of all parts in a system.

Filter bag performance is affected by proper fit and construction, as well as exposure to system conditions and mechanical wear. Additionally, the age and maintenance history of a system are significant contributors to its effectiveness.

The industry consensus is that the best available fabric filtration technology is expanded polytetrafluoroethylene (ePTFE) laminated to base filtration fabrics. This media is exceptionally efficient in capturing particulate on the collection surface of a filter bag without having to rely on a dust-cake or control layer. The majority of kiln and kiln/raw mill baghouses in North America are already successfully using this technology.

What is known

A properly designed and maintained dust collector with a newly installed full set of ePTFE laminated filters can meet the very low emissions numbers required by the proposed NESHAP rule. The numbers that were the basis for the proposed regulation came from actual stack test data.

Then what is the problem?

The challenge is a lack of data available for historic continuous outlet emissions with these systems that shows at what point in the filter's life the emissions begin increasing. In short, the limits are achievable but the information regarding reasonable duration is still unknown.

How and when do emissions occur?

First, assume that there are no emission points relating to the dirty and clean baghouse interfaces such as breeches in weld seams, no superfluous dust sources like rust scale, and filter seals are intact and properly installed. ePTFE membrane eventually fractures along the flex lines corresponding with the support cage wires, or in the case of reverse air filters, along the flex lines created during cleaning action. The formation of these fissures is directly proportional to cleaning cycle exposure. Once the integrity of the membrane is compromised, dust particles can penetrate along these fissure lines.

Why is there a variance in filter performance from one baghouse to another?

Design, operation, age and process conditions all contribute to filter life. Expecting the same performance from the same filters installed in two different baghouses is akin to presuming similar performance from an identical pair of tyres on two different vehicles, driven by different drivers under different road conditions.

What about leakage through stitching on filter bag seams?

Based on a hypothesis that dust penetration could potentially occur at the needle holes in the filter bag seams, test results from a recently published study showed that sealing the seam via taping reduced particulate emissions. Separate testing commissioned by Parker Hannifin, formerly GE Environmental Services adhering to the US EPA's Environmental Testing Verification (ETV) testing protocol yielded different results.1

Why the difference? Results that showed the positive impact of taping the seams were drawn from data obtained during the 'seasoning' or 'conditioning' phase of testing. However, ETV protocol does not draw testing conclusions from results taken during the seasoning phase.

ETV testing has three phases. An initial conditioning or seasoning phase consists of 10 000 rapid filter pulse filtration cycles to simulate long-term operation. Second, a recovery phase consists of 30 'normal' filtration cycles (cleaning once 4 in. DP is reached) to allow recovery from the rapid cycle cleaning phase. The third and final phase is the actual testing phase, which consists of normal filtration cycles and simulates conditions that are as close to normal baghouse operation as possible in a laboratory setting. The actual testing phase lasts six hours.

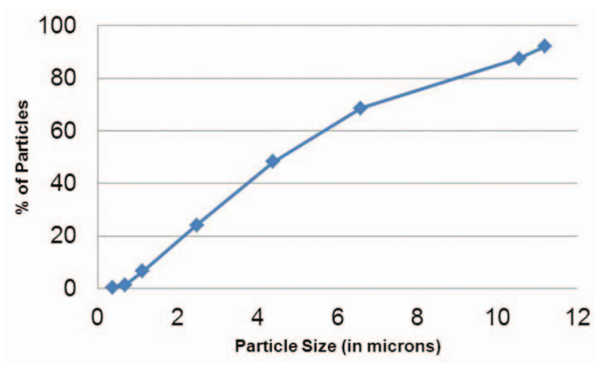

Figure 1. CKD sample particle size distribution chart

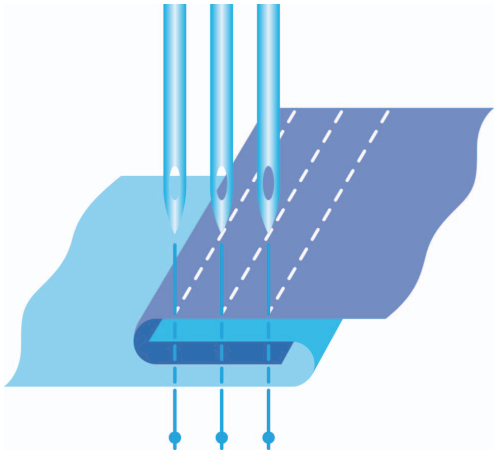

Figure 2. Stitching construction.

Table 1. ETS test data			
	Sample stitched with E-12 threads	Sample stitched with Rastex® threads	Sample stitched with E-12 threads and then seam- sealed
Mean outlet particle concentration (gr/dscf) PM2.5	0.0000007	0.0000007	0.0000007
Mean outlet particle concentration – total mass (gr/dscf)	0.0000088	0.0000048	0.0000014
Removal efficiency of PM2.5 (%)	99.99999	99.99998	99.99999
Removal efficiency – total mass (%)	99.99999	99.99994	99.99998

ETV test results

In order to get an accurate picture of the performance of stitched and taped seams, submitted filter samples were submitted to ETS Inc., an independent laboratory, for testing per the US EPA's Environmental Technology Verification (ETV) programme. Testing is conducted according to ASTM Test Method D6830-02, with test parameters as described in the ETV programme. The sample holder in the test instrument is adapted to include a section of a vertical bag seam from the test samples.

To conduct tests that were meaningful to actual application, a sample of cement kiln dust (CKD) was obtained for testing from a cement plant in Humboldt, Kansas. The properties of this CKD were as follows:

- Mass mean diameter ~4.5 µm.
- Percentage below PM2.5 ~24.24%.

Figure 1 shows a plot of particle size distribution of the CKD sample. The x-axis represents particle sizes (µm), and the y-axis plots the total percentages of the CKD sample for the range of particle sizes.

Three filter seam samples were tested by ETS Inc. All three samples used 22 oz. woven fibreglass media with ePTFE membrane. The test samples were as follows:

1. Media stitched with PTFE-coated Fibreglass E-12 threads.
2. Media stitched with Rastex® threads.
3. Media stitched with E-12 threads and then seam- sealed.

The stitching represented the vertical bag seam construction (felled seams) used by Parker in its filter bags. Figure 2 shows the stitching construction.

Table 1 summarises the test data from ETS conducted per the ETV test protocol. Two conclusions can be drawn from this data:

- When tested with actual CKD, minimal to no differences in emissions were observed between E-12 thread, Rastex® thread, or seam-sealed seams.
- In actual application, any differences could be expected to be even lower because the seam as a percentage of total filtration area is even less than what was tested.

Based on this testing, it does not appear that tape sealing of the seams offers any significant additional benefit for reduction or prevention of emissions through filter bags.

Seam-sealing did not demonstrate a material decrease in emissions in these tests for several reasons:

- With the felled seam construction of the samples tested, there are four layers of base fabric media that dust must pass through, which inhibits emissions.
- The 22 oz. woven fibreglass media with ePTFE membrane laminate has higher filtration efficiency than many other similar options available in the market.
- As each needle hole is filled with thread, voids are minimised and emission pathways are restricted.

In application, seams that have also been taped could actually reduce some of the effective total filtration area of the bag.

What does this mean for 'real-life' installations?

Based on stack test data that has been used to set the proposed NESHAP limits, newly installed ePTFE membrane filters can meet low PM emission requirements.

Any protection offered by taped seams occurred during the seasoning phase of testing only. Results do not support the idea that taped seams offer any significant additional benefits compared to stitched seams.

The test shows that the standard felled seam construction on filter bags during the appropriate testing phase (as well as the conditioning phase) in the ETV protocol is not a source of increased PM emissions.

While a 'magic filter bag' may continue to be elusive, the current technology available – filters with ePTFE membrane – remains an effective solution for meeting today's emissions requirements as well as tomorrow's proposed NESHAP limits.

References

1. Additional information about the ETV testing protocol can be found at the US Environmental Protection Agency website: http://www.epa.gov/etv/pubs/05_vp_bfp.pdf.

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