

DESIGN AND TESTING OF ANTISTATIC FILTERS FOR INDUSTRIAL AIR FILTRATION

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INTRODUCTION

In many industrial dust collection systems, the filtration and electrical properties of the filter media play an important role in the performance and safety of the system. If the dust being collected is fine, difficult to capture, or has a high intrinsic value, the filtration effectiveness of the media is important. Furthermore, during processing, electric charges can develop. If the filter media cannot dissipate the electric charge, there is a chance of unwanted build-up and electrostatic discharge (ESD). ESD can lead to explosions, fires, or personal injury from shock.

This paper will examine the filtration and electrical properties of both conventional (non-membrane) filters and filters using expanded polytetrafluoroethylene (ePTFE) membrane as the filtration surface. All materials discussed are polyester nonwoven needlefelts. Recent advances in membrane performance will be discussed. Test results from the National Fire Protection Association-99 (NFPA-99) static-dissipation test method and the Deutsches Institut fuer Normung 54345 Part 5 (DIN 543455) electrical conductivity test method will be

presented. While there are a number of different test methods available, these are among the most commonly referenced in industrial filtration.

ANTISTATIC FILTERS IN PULSE JET BAGHOUSES FOR INDUSTRIAL FILTRATION

During manufacturing and conveying, fine particulates can collect electrical charges as they impact other particles and ductwork. If these charges are not “drained” from the system, they can build up to such a level that a spark or ESD occurs. Under certain conditions, this could lead to an explosion or fire in the baghouse. In the paper entitled “Brace Your Plant Against a Dust Explosion,”¹ Thomas Godbey describes these conditions as “...a combustible dust, air, or another oxidant, and a source of ignition.”

In baghouse applications with fine particulates, steps should be taken to reduce or eliminate the buildup of electrical charges. As discussed in the literature,^{2,3} there are generally two approaches when using fabric filtration media: 1) the use of antistatic agents, and 2) the use of special antistatic or conductive fibers. These

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antistatic fibers are added to a base material in a low percentage (2-6%) and form an intricate network through the cross-section of a filter. When properly dispersed, these fibers serve to conduct the electrical charge. As shown in Figure 1, the fibers are intricately mixed with the base fibers (e.g., polyester) during the felting operation. In all cases, it is important that filters of this type use a groundwire. When properly installed, this groundwire serves to ground the cage to the tubesheet.

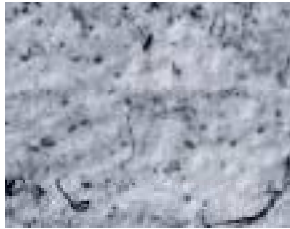


Figure 1: Top view of polyester felt with conductive fibers (black)

ELECTRICAL PROPERTIES

When testing the electrical properties of a filter media, there are two common test methods. The test method used in the United States is the INDA Standard Test for Electrostatic Decay (IST 40.2-92).⁴ This standard references the NFPA, Code 99, Chapter 12 using Method 4046 of Federal Test Method Standard 101C and measures the static dissipative properties of a material. In Germany, the DIN 54345 Part 5⁵ method is preferred. This test is used to measure the electrical resistance of a particular material.

Both test methods identify materials that are electrically conducting and those that are electrically insulating.

Static Dissipation: NFPA-99 is used to measure the capability of a material to drain an induced electrical charge by measuring the length of time (seconds) it takes for a 5,000 volt charge to drain to 500 volts. In order to pass the test, a material must drain the charge in less than 0.5 seconds. It is believed that this test closely duplicates the conditions in a baghouse environment. In these cases, it is difficult to prevent the creation of electrostatic charges. There is also a need for quick dissipation of any charge.

Electrical Resistance: In Germany, the use of the DIN 54345 Part 5 is more common. In this test method, the electrical resistance of a material is measured. A material passes the test if the measured resistance is lower than $1 \times 10^8 \Omega$. This test determines the electrical resistance of materials, including those utilizing epitropic fibers. Unlike the NFPA test method, the DIN test is based on the assumption that a material's electrical resistance is the important criteria in applications subject to the development of static charges.

It is not the purpose of this paper to determine which test method is preferable for baghouse applications. The goal is to make the reader aware of the different standards being used globally so an informed decision can be made as to the applicability of the tests.

FILTRATION PROPERTIES

There are generally two types of filtration seen in industrial baghouses:

- 1) conventional filtration (depth) and
- 2) membrane filtration (surface). The filtration efficiency of conventional felts

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depends on the intricate entanglement of the fibers, and the filtration effectiveness of the subsequent dust cake layer that builds up on the surface. Optimum filtering occurs only after sufficient dust builds up on the filter's surface.

Because ePTFE membrane is a continuous layer on the filtration surface, it does not require the development of a surface dust layer to achieve maximum effectiveness. Figure 2 shows the difference between the two types of filter media at different magnifications. The photos on the left show the ePTFE membrane surface. The membrane provides a continuous filtration surface which captures the dust particles. With conventional filtration, there is no continuous filtration surface. Filtration efficiency depends on the intricate entanglement of the fibers. The dust particles trapped within the felt structure are seen. Over time, the dust will build up, resulting in higher pressure drops and particulate emissions.



Figure 2: Membrane vs. conventional filtration

The ePTFE membrane sample achieves maximum filtration efficiency immediately. The membrane is a continuous filtration layer and the backing material is only used as a support structure. Figure 3 is a cross-sectional view of an ePTFE membrane laminated to felt backer.

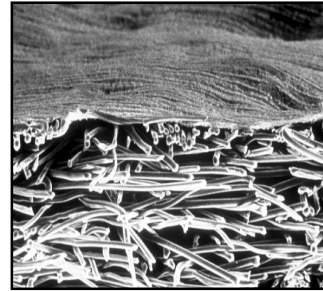


Figure 3: Cross-section of filtration media showing the ePTFE membrane and backing.

The efficiency of all industrial filters can be reduced by damage during operation. In a conventional bag, the efficiency may be reduced as a result of mechanical stretching of the felt (especially on scrimless felts).

There can be a decrease in efficiency of a membrane filter as well. This damage is usually the result of mechanical wear during the cleaning cycle. Recent advances in membrane technology at W. L. Gore & Associates, Inc. have minimized this damage. A new series of patented⁶ membranes have been engineered to be stronger, while still providing the same or higher airflow. Figure 4 shows the membrane permeability vs. strength of several membrane groups. Series A represents some of the earliest membranes developed for industrial filtration, while series D shows some of the newest membranes. The new membranes have more than double the strength of the oldest membranes at the same permeability.

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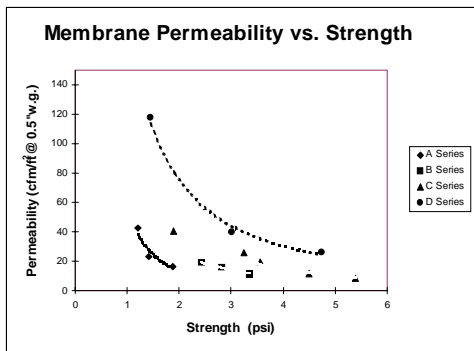


Figure 4: Comparison of permeability vs. strength for ePTFE membranes

In use, these new membranes resist damage better than earlier membranes. As can be seen in Figure 5, “cracks” are visible and provide a path for particulate emissions. Damage is usually seen on or near the vertical cage wires where bag movement during cleaning is highest.

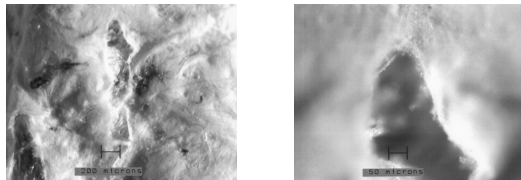


Figure 5: Photographs showing membrane cracking (16 months service)

Figure 6 shows the backside of two used filters. Both have an ePTFE membrane as the filtration surface. The filter on the right uses the new membrane. In the photo, the dark spots represent areas where dust has penetrated the felt due to membrane cracks. The sample on the left has significantly fewer spots. These samples had been in service for 9 months. While the amount of damage will depend on baghouse operating conditions, it is expected that these new membranes will result in a more durably efficient filter.

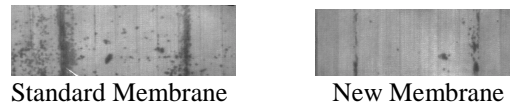


Figure 6: Photographs of the backside of used filters (9 months service)

ELECTRICAL PROPERTY TESTING

Results: Four different felt materials were evaluated for electrical properties. These samples included: 1) 14 oz/yd² polyester felt with carbon-filled ePTFE fibers with ePTFE membrane, 2) conventional 14 oz/yd² polyester felt with carbon-filled ePTFE fibers, 3) conventional 16 oz/yd² polyester felt with epitropic polyester fibers, and 4) conventional 16 oz/yd² polyester felt with stainless steel fibers.

Each of these materials (except #2) is commercially available and is used for industrial filtration applications. Sample 2 is not commercially available without a membrane. It was tested to evaluate the effect of the ePTFE membrane on both electrical and filtration performance.

NFPA: This test was conducted at an independent laboratory in Canada. As Figure 7 shows, all materials passed with a decay time of 0.01 seconds. Interestingly, even though ePTFE is considered to be an insulator, there does not appear to be a detrimental affect from its use.

Additionally, regardless of the antistatic fiber used, all materials passed the test.

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Specimen (All are polyester felt)	Filtration Side (average)		Back Side (average)	
	+5kV	-5kV	+5kV	-5kV
Epitropic Polyester Fibers	0.01	0.01	0.01	0.01
Stainless Steel Fibers	0.01	0.01	0.01	0.01
Carbon-Filled ePTFE Fibers	0.01	0.01	0.01	0.01
Carbon-Filled ePTFE Fibers and ePTFE Membrane	0.01	0.01	0.01	0.01

Figure 7: Static decay time comparison (seconds)

When an ePTFE membrane is used, the use of either the carbon-filled ePTFE fibers or epitropic polyester fibers is preferred over stainless steel. It is believed that, due to their high stiffness, the stainless steel fibers can cause damage to the membrane. This would detrimentally affect the filter's efficiency. An advantage of the ePTFE fiber is their high chemical resistance and thermal properties. These fibers can be used up to 260°C and can be combined with any filtration fiber, including PTFE. The epitropic polyester fibers can only be effectively used in polyester fiber-based materials.

DIN 54345 Part 5: An independent testing laboratory in Germany tested samples of the same materials used in the NFPA test. The test results are shown below in Figure 8.

Specimen (All are polyester felt)	Electrical Resistance (Ω)		Electrode Spacing (mm)
	Machine Direction	Cross-Machine Direction	
Epitropic Polyester Fibers	1.2×10^7	5.4×10^6	30
Stainless Steel Fibers	$< 1 \times 10^4$	$< 1 \times 10^4$	30
Carbon-Filled ePTFE Fibers	3.1×10^7	1.4×10^6	30
Carbon-Filled ePTFE Fibers and ePTFE Membrane	1.2×10^7	1.2×10^6	30

Figure 8: DIN test results (DIN 54345 Part 5)

The results for the ePTFE membrane sample indicate that although ePTFE is an insulator, it does not significantly affect the ability of the filter to pass the test. This is likely the

result of the fact that the membrane is thin and has a good bond to the conductive fibers within the backing material.

While not tested for this paper, W. L. Gore & Associates, Inc. has recently commercialized filter media⁷ that incorporates a patented conductive membrane. This membrane uses special conductive carbon particles to enhance its electrical properties. Filtration products based on these membranes will be discussed in upcoming papers.

The DIN testing results show an expected, but interesting, phenomenon. The electrical resistance changes depending on the original orientation of the test sample. The reason is that during the felting process, the fibers are preferentially oriented in one direction. This is not an indication of a problem in felting. It is characteristic of felted materials.

EFFICIENCY TESTING

Results: All comparative efficiency testing was done on new samples (tests were conducted at W. L. Gore & Associates, Inc.). These efficiencies were measured using a TSI, Inc., AFT 8160 Automated Filter Tester. As shown in Figure 9, initial efficiency of the non-membrane materials is significantly lower than the sample with ePTFE membrane. Conventional filters do not reach maximum filtration efficiency until both the primary cake (within the felt) and the secondary cake (on the surface) have developed.

Efficiency must be considered in two ways: 1) initial efficiency, and 2) long-term efficiency. In industrial filtration

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applications, efficiency changes over time due to seasoning effects and filter durability.

Particle Size (μm)	Conventional Polyester Felt with SS fibers	Conventional Polyester Felt with Epitropic Polyester Fibers	Conventional Polyester Felt with Carbon-Filled ePTFE Fibers	Polyester Felt with Carbon-Filled ePTFE Fibers and ePTFE Membrane
0.03	73.60	71.53	74.11	97.92
0.04	66.65	64.18	66.86	96.98
0.05	58.81	57.02	59.18	96.02
0.07	50.88	48.21	49.60	94.74
0.1	40.30	39.02	41.41	94.55
0.15	32.32	29.84	32.90	95.29
0.2	23.92	22.86	25.70	96.43
0.3	18.87	19.53	20.41	98.12

Figure 9: Filtration efficiency (count basis, face velocity = 5.0 cm/sec): comparison of antistatic polyester felts.

CONCLUSION

As dry chemical producers continue to develop finer products, the need for high efficiency, static dissipating filters increases. The demands placed on filters require higher performance materials providing long service life. The data presented shows that chemical producers have a number of viable filtration products from which to choose.

The chemical producer should consider a filter media's:

- 1) electrical properties
- 2) filtration properties

Prior to selecting a filter for your application, all relevant regulatory and insurance requirements should be considered.

Today's filtration products companies are assisting chemical producers in meeting their filtration needs. The benefits of these filters include improved filtration efficiency and static electricity dissipation to minimize the chance of electrostatic discharge.

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