Auburn FilterSense

“Best Practices for Bag Leak Detection Systems in Clean Air Act Permitting”

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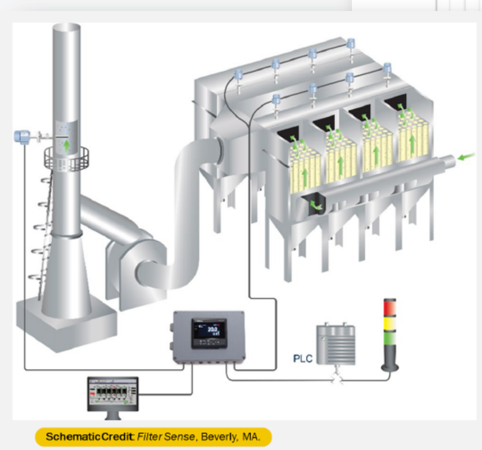
See Auburn FilterSense Highlights on pages 1, 3 and 9.



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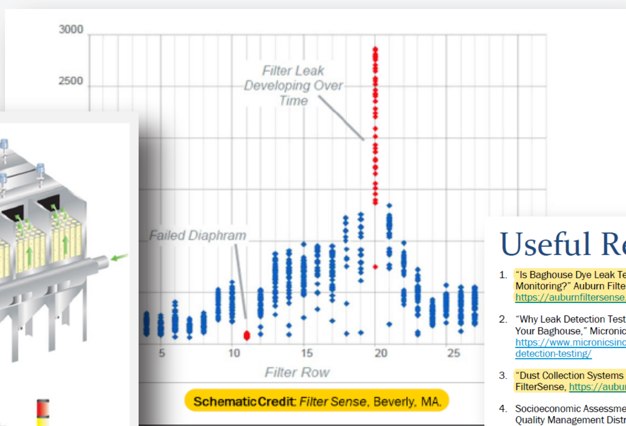

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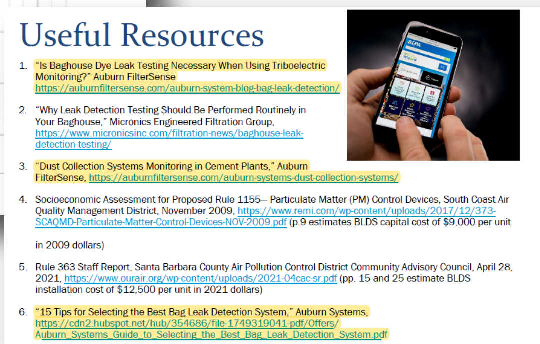

Useful Resources

1. “Is Baghouse Dye Leak Testing Necessary When Using Triboelectric Monitoring?” Auburn FilterSense https://auburnfiltersense.com/auburn-system-blog-bag-leak-detection/
2. “Why Leak Detection Testing Should Be Performed Routinely in Your Baghouse,” Micronics Engineered Filtration Group, https://www.micronicsinc.com/filtration-news/baghouse-leak-detection-testing/
3. “Dust Collection Systems Monitoring in Cement Plants,” Auburn FilterSense, https://auburnfiltersense.com/auburn-systems-dust-collection-systems/
4. Socioeconomic Assessment for Proposed Rule 1155– Particulate Matter (PM) Control Devices, South Coast Air Quality Management District, November 2009, https://www.remi.com/wp-content/uploads/2017/12/373-SCAQMD-Particulate-Matter-Control-Devices-NOV-2009.pdf (p.9 estimates BLDS capital cost of $9,000 per unit in 2009 dollars)
5. Rule 363 Staff Report, Santa Barbara County Air Pollution Control District Community Advisory Council, April 28, 2021, https://www.ourair.org/wp-content/uploads/2021-04cac-sr.pdf (pp. 15 and 25 estimate BLDS installation cost of $12,500 per unit in 2021 dollars)
6. “15 Tips for Selecting the Best Bag Leak Detection System,” Auburn Systems, https://cdn2.hubspot.net/hub/354686/file-1749319041-pdf/Offers/Auburn_Systems_Guide_to_Selecting_the_Best_Bag_Leak_Detection_System.pdf

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Best Practices for Bag Leak Detection Systems in Clean Air Act Permitting

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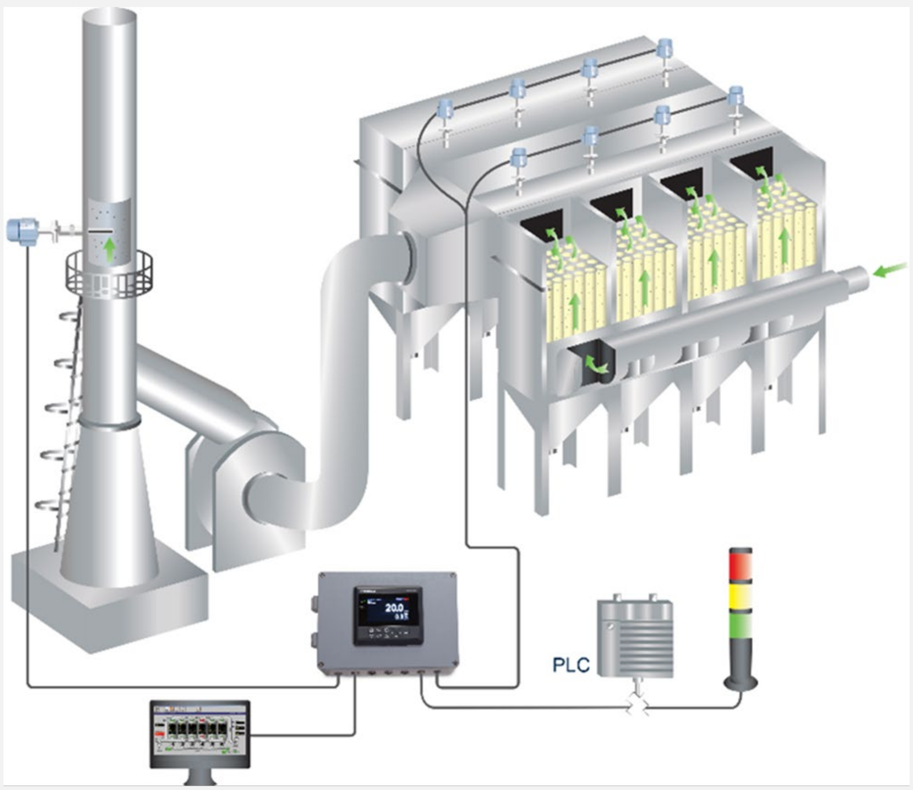
What are Bag Leak Detection Systems?

A Bag Leak Detection System (BLDS) refers to an instrument that monitors particulate matter (PM) in the exhaust stream of a fabric filter control device (*i.e.*, baghouse) to detect bag failures or filter media degradation. A BLDS includes, but is not limited to, an instrument that operates on triboelectric, light scattering, light transmittance, or other measurement technique to monitor relative PM loadings in the exhaust stream.

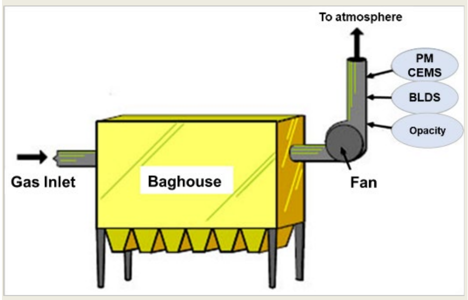


Schematic Credit: *Filter Sense*, Beverly, MA.

If the PM readings rise, the BLDS can automatically trigger a relay alarm to indicate that a failure has occurred, or is about to occur, and display the emissions data in real time for operators to monitor. A BLDS can be installed on new or existing baghouses whose filters are in the form of cylindrical fabric bags or cartridges that are constructed of fabric, sintered metal or porous ceramic. Special installation may be required for positive pressure baghouses and baghouses without stacks.

This document recommends best practices for the installation and operation of BLDS monitors used for compliance with Clean Air Act (CAA) requirements. These best practices are for consideration in CAA permitting actions involving fabric filter control devices and do not express or imply any CAA requirements to which a source may be subject. While the best practices discussed herein are written to generally apply to all types of BLDS monitors, some of the best practices may be more suitable for triboelectric BLDS monitors than other types of monitors. The device's manufacturer should be consulted to resolve any concerns with the applicability of specific best practices. Any mention of trade names, manufacturers, or products in this document does not imply an endorsement by EPA.

A BLDS typically does not require any special actions or personnel to initiate operation of the device since the system would be wired to be powered whenever the baghouse fan motor is operating.



BLDS Advantages

1. Early Warning for Leaks and Pending Bag Failures
2. Isolation of Leaks in Multi-Compartment Baghouses
3. Proactive and Efficient Maintenance of the Baghouse
4. Capability to Provide a Quantitative Measurement of PM Emissions by Correlating with Stack Test Data

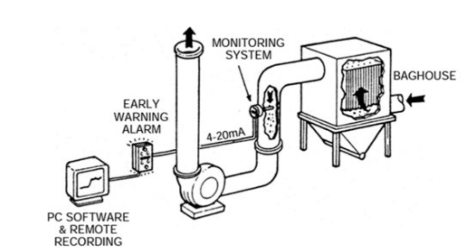
How are fabric filter leaks typically monitored or detected?

Manufacturers of fabric filters recommend, and regulatory agencies often require, monitoring to detect poor or deteriorating baghouse performance. Monitoring methods typically involve manually or electronically reading critical operating parameters (such as pressure drop and visible emissions) and recording the values periodically (*e.g.*, daily). Operators may also periodically conduct leak testing using fluorescent dye.

- **Pressure Drop and Other Parametric Monitoring.** Indicators of fabric filter performance include pressure differential, inlet temperature, temperature differential, exhaust gas flow rate, fan current, opacity and PM emissions. These indicators should be assessed for appropriateness, and selected indicators should be continuously monitored and recorded. Where readings are taken or recorded manually (*e.g.*, pressure drop or temperature readings taken or logged daily), operational efficiency and the ability to assure continuous compliance may be compromised, and costly additional labor resources are usually needed.

- **Dye Leak Testing.** Manufacturers of baghouses and dust collectors often recommend leak testing (such as dye leak testing) as part of a comprehensive and routine preventive maintenance plan. Dye leak testing involves a technician injecting a fluorescent powder upstream of the baghouse. With the system running, the powder is pulled through the unit and dispersed evenly throughout the entire unit, which causes a larger buildup of the dye powder at the point of the leak.[Ref. 1, 2] After operating for a period of time (typically 5 minutes or longer), the unit is then shut down and a technician uses a black light to identify any leaks in the filters by looking for areas where more of the dye has built up due to the air rushing to that spot while following the path of least resistance. Dye leak testing enables the technician to inspect the filter media much quicker and more thoroughly than just a visual inspection. A BLDS can supplement or, in some situations, replace baghouse leak testing.

- **Visible Emissions (Opacity) Monitoring and Stack Testing.** Permits and state and federal rules typically include provisions for periodic monitoring of the opacity of emissions discharged from baghouses. This monitoring is usually conducted by trained observers on a daily, monthly or even longer frequency following EPA Method 22 or Method 9 contained in Appendix A of 40 CFR Part 60. As emissions and need for control device operation rise in importance, continuous opacity monitors (COMS) or PM continuous emissions monitors (CEMS) may be required. Such measurements when properly conducted can detect when the baghouse is not operating as intended, such as when there are broken or failing bags, which can trigger further investigation to isolate the culprit bags. However, the periodic nature of visible emissions observations means that leaks can occur for days or even months before they are caught and repaired. Additionally, on large multi-compartment dust collection systems, COMS and PM CEMS installed on the main stack are not capable of detecting a leaking filter as quickly as a BLDS installed in the compartment outlet. The delay until the leak becomes visible



The BLDS' early warning system can:

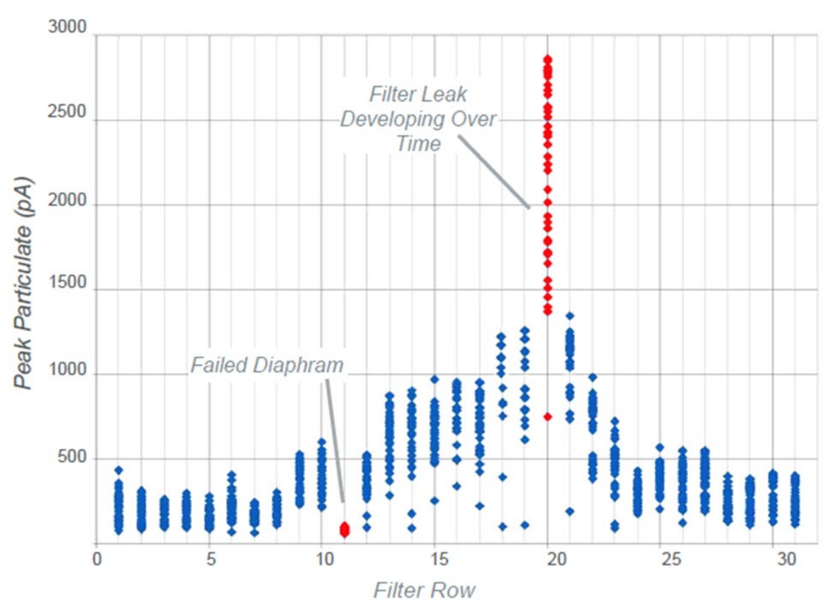
- significantly reduce the time required for finding and repairing leaks
- save resources needed for finding and repairing leaks
- lead to enhanced compliance with regulatory requirements
- lead to, and encourage, emissions reductions to protect communities

emissions can be days, which often allows a leak to enlarge to a significant size before it is discovered and repaired.[Ref.3] Leaks, if not promptly addressed, can result in opacity excursions or violations that require a significant amount of remediation work to clean out the compartment.[Ref.3]

- **Visual Equipment Inspections.** Control equipment inspections are conducted periodically as recommended by the equipment manufacturer or according to a regulatory requirement. Inspections may also be conducted as a corrective action in response to a malfunction or an emissions or parametric excursion. These inspections may involve shutting down the process generating emissions, which may result in lost production.

Why Use BLDS?

Although other effective and occasionally cheaper monitoring options exist as discussed above, a BLDS can offer many advantages to both facility operators and industry depending on the application. When properly installed, operation of a BLDS typically does not require any special actions or personnel to initiate operation of the device since the system would be wired to be powered whenever the baghouse fan motor is operating. Key advantages of a BLDS include, but are not limited to:



Schematic Credit: *Filter Sense*, Beverly, MA.

- **Early Warning for Leaks and Pending Bag Failures.** Fabric filter bag failures can come from many sources, including improper bag fit or installation, spark holes, abrasion, thermal excursions, or chemical conditions in the gas stream, among others. BLDS monitors provide early warning of impending leaks and bag failures by alerting personnel at the very beginnings of a leakage before the leakage turns into a violation or otherwise reportable event. A BLDS can reduce the time required for finding leaks to minutes, tracking leaks down to the specific unit, compartment and even row of bags.[Ref.3]

Best Practices

1. Evaluate BLDS monitors as part of an integrated solution.
2. Install a BLDS on each medium or large size baghouse that does not include a COMS or PM CEMS.
3. Use a BLDS that can detect PM emissions at concentrations of 1.0 mg/acm (0.00044 gr/acf) or less.
4. Install a visual and audible alarm that will sound automatically when it detects an increase in relative PM emissions greater than a preset level (setpoint).
5. Develop and follow a site-specific monitoring plan.
6. If the BLDS is to be used for compliance, submit the site-specific monitoring plan to the regulatory agency for review and approval.

- **Readily Isolate Leaks in Multi-Compartment Baghouses.** A BLDS sensor installed on each compartment of a multi-compartment baghouse or dust collector rather than just one on the common outlet or main stack enables leaks to be isolated to a particular compartment of the system.[Ref.3] Further, depending on baghouse type, the location of the leak can be narrowed to a particular row of filters. This may narrow the scope of further investigation from thousands of bags down to only a dozen or so. The ability of a BLDS to quickly detect leaking filters explains why BLDS monitors are often appropriately referred to as broken bag or bag leak detectors.

- **Proactive and Efficient Maintenance of the Baghouse.** The best indicator of fabric filter performance is the outlet PM concentration, which can be measured with a PM CEMS or a BLDS. The high sensitivity of the BLDS provides operators with the ability to accurately predict when filters will need to be replaced, allowing for more efficient management of filter service life and potentially reducing production downtime, maintenance labor and media costs. A BLDS can detect a filter leak before it occurs and can reduce maintenance time by pinpointing the leaking filter to a certain area. Moreover, with an estimated capital cost of less than $15,000 per unit and minimal routine maintenance costs after the initial testing phase,[Ref.4, 5] the BLDS can achieve cost savings in terms of reduced baghouse maintenance, reduced lost production or lost product (depending on the baghouse application), avoided compliance enforcement penalties, reduced compliance reporting obligations, and reduced permit fees due to reductions in PM emissions.

- **When Properly Correlated with a Stack Test, the BLDS Output Can Provide a Quantitative Measurement of PM Emissions.** A BLDS qualitatively indicates relative changes in particular concentrations. However, when correlated with a stack test using Performance Specification 11, a triboelectric BLDS can also provide a quantitative measurement of PM emissions in pounds per hour (lb/hr), micrograms per cubic meter ($\mu g/m^3$), or other specific value, since the triboelectric current is proportional to the mass concentration of the PM.

Best Practices

1. Evaluate BLDS monitors as part of an integrated solution, including reporting and integration with existing control systems, and not just for leak detection or compliance.

As BLDS circuitry, signal processing, noise suppression and probe technologies have improved in recent years, some of the most significant improvements in BLDS technology have come in advances in networking multiple sensors, centralized monitoring and logging of data and the ability of BLDS to communicate with factory control systems (including remote or off-site systems) to request or exchange various other parametric values.[Ref.6] Today's systems, properly specified for an application, provide enormous breadth of data collection, monitoring and reporting capability

Best Practices (Cont'd)

7. Exercise caution before making significant adjustments to the system's sensitivity, averaging period and alarm setpoints.
8. When an alarm is triggered, initiate corrective actions promptly.
9. Use periodic visible emissions observations and PM stack tests to confirm the effectiveness of BLDS monitors.
10. Continue to monitor other indicators of baghouse performance as recommended by the system manufacturer.
11. Use dye leak testing to compliment the BLDS as needed.
12. Maintain adequate records

not only in support of compliance, but potentially enabling improvements in manufacturing efficiency and reductions in cost.[Ref.6] We recommend facilities and regulators evaluate BLDS monitors as part of an integrated solution to improve facility compliance with applicable requirements.

2. Consider installing and continuously operating a BLDS on each fabric filter baghouse that does not include a COMS or PM CEMS.

Evaluate BLDS monitors for each medium or large size fabric filter baghouse with a filter surface area of 7,500 square feet or more. The BLDS should include sensors installed in the exhaust stack and on each compartment of a multi-compartment baghouse, powered by a Programmable Logic Controller (PLC) and should produce a continuous analog output signal. For a positive-pressure fabric filter baghouse, consider having each compartment or cell contain a BLDS sensor. For a negative-pressure or induced-air fabric filter baghouse, the BLDS sensor should be installed downstream of the baghouse and upstream of any wet scrubber. The BLDS sensors should provide output of relative PM loadings and the output should be continuously recorded using electronic or other means such as a strip chart recorder or a data logger. If multiple BLDS sensors are installed, sensors may share the system instrumentation including the PLC and data recording devices.

3. Utilize a BLDS that is capable of detecting PM emissions at concentrations of 1.0 milligrams per actual cubic meter (1.0 mg/acm) (*i.e.*, 0.00044 grains per actual cubic foot, gr/acf) or less.

This detection level is the minimum BLDS detection level prescribed in EPA's federal rules (see, *e.g.*, 40 CFR 63.1206(c)) and reflects the detection capability of modern BLDS systems.[Ref.9] Regulatory agencies may approve a higher detection limit (not to exceed 10 mg/acm (0.0044 gr/acf) specified in EPA's regulations) on a case-by-case basis if it can be shown that a lower detection level is unachievable and the higher detection limit would be sufficient to routinely detect PM loadings during normal operations of the subject facility. Specific procedures for determination and reporting of the detection limit for each BLDS model are contained in ASTM D7392-07.[Ref.9]

4. The BLDS should have a visual and audible alarm that will sound automatically when it detects an increase in relative PM emissions greater than a preset level (setpoint).

The alarm should be in an area where appropriate plant personnel will be able to hear and see it. The alarm setpoints will serve as an early warning sign for a pending bag failure or other malfunction and should be automatically triggered when the PM loadings reach the setpoints. If multiple BLDS sensors are installed, sensors may share the alarm.

BLDS Maintenance

1. Conduct a BLDS response test at least monthly.
2. Conduct an electronics drift check at least monthly.
3. Visually inspect the sensor probe at least semi-annually and after each alarm condition.
4. Evaluate and adjust the BLDS monitor's settings at least annually.

When an alarm is triggered, promptly initiate corrective actions to resolve the alarm within 3 hours from the time the alarm occurred.

5. Install, operate, adjust, and maintain BLDS monitors and associated sensors, PLC and data recording systems according to a site-specific monitoring plan and manufacturer's recommendations.

Each triboelectric BLDS should be installed, operated, adjusted, and maintained so that it follows EPA's guidance for triboelectric BLDS monitors[Ref.7] and a site-specific monitoring plan. Other BLDS monitors should follow the manufacturer's written specifications and recommendations and the site-specific monitoring plan. Routine maintenance should include, but not be limited to, a BLDS response test on a periodic basis (at least monthly); an electronics drift check on a periodic basis (at least monthly); periodic visual inspection of the sensor probe for evidence of water leakage (*e.g.*, rain) and potential dust build-up on the leading edge of the probe (at least semi-annually and after each alarm condition); and periodic evaluation and adjustment of the monitor's settings (at least annually).

6. To ensure the BLDS operates in a manner sufficient for regulatory compliance, the site-specific monitoring plan should be submitted to the regulatory agency for review and approval.

The site-specific monitoring plan should describe: the BLDS components and associated equipment and sensor locations within the facility; procedures for initial and periodic adjustment of the BLDS including how the alarm setpoint will be established and adjusted if necessary; how the BLDS will be operated and maintained including quality assurance procedures, a routine maintenance schedule and procedures, and an inventory of spare parts to be retained onsite; how the BLDS output will be recorded and stored; corrective actions to be taken if an alarm is triggered; and the identification of facility personnel responsible for operation and maintenance of the BLDS.

7. Exercise caution and consult with the regulatory agency (as applicable) before making significant adjustments to the system's sensitivity, averaging period and alarm setpoints.

The initial adjustment of the BLDS consists of establishing the baseline output by adjusting the sensitivity (range) and the averaging period of the device and establishing the alarm setpoints and the alarm delay time, if applicable. After initial adjustment, further adjustments to the range, averaging period, alarm setpoints, or alarm delay time should not be made except as specified in the site-specific monitoring plan. If provided in the site-specific monitoring plan, the range may generally be adjusted periodically (*e.g.*, quarterly) to account for seasonal effects including temperature and humidity. Additionally, if opacities greater than a predetermined baseline value (*e.g.*, zero percent) are observed and the alarm on the BLDS does not sound, the alarm setpoint should be lowered to a point where the alarm would have sounded during the period when the opacity observations were made. In general, significant adjustments to the range (*e.g.*, increasing by more than 100 percent or decreasing by more

CORRECTIVE ACTIONS AFTER AN ALARM CONDITION

1. Initiate a root cause analysis within one hour of the alarm.
2. Inspect the baghouse for air leaks, torn or broken bags or filter media, or any other condition that may cause an increase in PM emissions.
3. Seal off defective bags or filter media.
4. Replace or repair defective bags or filter media.
5. Seal off defective baghouse compartment.
6. Clean or repair the BLDS probe.
7. If alarm persists after 3 hours, shut down the emissions unit.

than 50 percent) should not be made unless the fabric filter has been inspected and found to be in good operating condition.

8. When an alarm is triggered, corrective actions should be promptly initiated and documented.

Corrective actions include, but are not be limited to: a requirement for operators to initiate procedures to determine the cause of all alarms within one hour of an alarm, with a goal to alleviate the alarm within 3 hours of the time the alarm occurred; inspecting the baghouse for air leaks, torn or broken bags or filter media, or any other condition that may cause an increase in PM emissions; sealing off defective bags or filter media; replacing defective bags or filter media or otherwise repairing the control device; sealing off a defective baghouse compartment; cleaning the BLDS probe or otherwise repairing the BLDS; and, if necessary, shutting down the process producing the PM emissions.

9. Use periodic visible emissions observations and PM stack tests to confirm the effectiveness of BLDS monitors and to establish or confirm a relationship between BLDS readings and opacity and PM emissions.

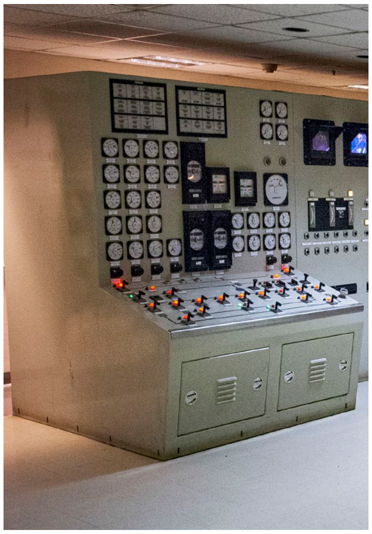
In a triboelectric BLDS, since the triboelectric current is proportional to the mass concentration of the PM, the BLDS measurement can be used as a qualitative monitor of PM emissions. This qualitative relationship between BLDS and opacity or PM can be established via EPA Methods 9 or 5 testing. However, the triboelectric signal must be correlated with a stack test using Performance Specification 11 to provide quantitative monitoring in lb/hr, $\mu g/m^3$, or other specific value. Use of the BLDS output in this manner for compliance purposes should be discussed and approved by the regulatory agency.

10. Continue to monitor and record other indicators of baghouse performance as recommended by the system manufacturer.

Conduct continuous monitoring and recordkeeping of critical performance indicators. This typically includes continuous monitoring and recordkeeping of pressure differential, inlet temperature, temperature differential, exhaust gas flow rate, pulse jet cleaning mechanism operating parameters, and/or fan current. Parametric ranges should be correlated with the BLDS output and stack test data if available.

11. Use dye leak testing to compliment the BLDS as needed. Dye leak testing may be necessary during troubleshooting or after new filter media is installed.

Consult with the baghouse's manufacturer on acceptable dye specifications and leak testing procedures. If dye leak testing reveals leaks that were not identified by the BLDS, it may be necessary to adjust the BLDS's range and alarm setpoints or locations of sensors.



12. Maintain adequate records.

The records should be sufficient to establish and confirm proper installation and operation of the BLDS and its sensors. The initial instrument set up procedures and records for all drift checks and response tests performed on the BLDS should be documented, including values for the baseline (sensitivity) setting, response time setting, and alarm level(s) and a description of how each was established. [Ref.7] Inspection records should include the date, time and condition of each sensor as-found, and a description of any actions taken during the inspection (*e.g.*, probe/insulator cleaning). For each BLDS alarm, records should include the date and time of the alarm, the time that procedures to determine the cause of the alarm were initiated, the cause of the alarm, an explanation of the actions taken, the date and time the cause of the alarm was alleviated, and whether the alarm was alleviated within 3 hours after the alarm. Each entry in the recordkeeping system should be signed by the person conducting the inspection, testing, or maintenance.

Who do I contact for more information?

United States Environmental Protection Agency

Region 5
Air & Radiation Division (AR-18J)
77 West Jackson Blvd
Chicago, Illinois 60604-3590
(312) 353-2000
R5AirPermits@epa.gov

https://www.epa.gov/caa-permitting/caa-permitting-epas-great-lakes-region

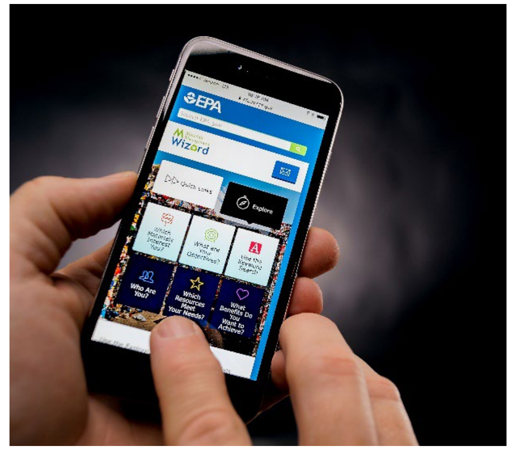
State/Tribal/Local Permitting Authorities

EPA has approved or delegated authority for the following Region 5 states and other jurisdictions to issue certain CAA permits:

- Illinois: https://epa.illinois.gov/topics/air-quality.html
- Indiana: https://www.in.gov/idem/airquality/index.htm
- Michigan: https://www.michigan.gov/egle/
- Minnesota: https://www.pca.state.mn.us/
- Ohio: https://www.epa.ohio.gov/

Wisconsin: https://dnr.wisconsin.gov/

Useful Resources



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3. “Dust Collection Systems Monitoring in Cement Plants,” Auburn FilterSense, https://auburnfiltersense.com/auburn-systems-dust-collection-systems/

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6. “15 Tips for Selecting the Best Bag Leak Detection System,” Auburn Systems, https://cdn2.hubspot.net/hub/354686/file-1749319041-pdf/Offers/Auburn_Systems_Guide_to_Selecting_the_Best_Bag_Leak_Detection_System.pdf

7. “Fabric Filter Bag Leak Detection Guidance,” EPA Office of Air Quality Planning and Standards, EPA–454/R–98–015, September 1997, https://www3.epa.gov/ttnemc01/cem/tribo.pdf

8. Sample federal rules that contain BLDS provisions:

   a. 40 CFR 62.14840 (defines BLDS for commercial and industrial solid waste incineration units)

   b. 40 CFR 63.1184 (design specifications, installation and operation of a BLDS for mineral wool production plants)

   c. 40 CFR 63.1206(c)(8) and (9) (BLDS requirements for hazardous waste combustors)

   d. 40 CFR 63.7710(b)(4) (site-specific monitoring plan requirements for iron and steel foundries)

   e. 40 CFR 63.11468 (BLDS requirements for secondary nonferrous metals processing area sources)

   f. ASTM D7392-07 (Standard Practice for PM Detector and Bag Leak Detector Manufacturers to Certify Conformance with Design and Performance Specifications for Cement Plants)