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Seeing the Small Stuff

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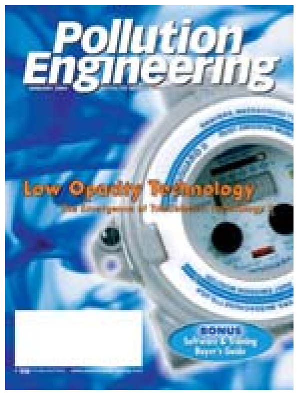


The Emergence of Triboelectric Technology II

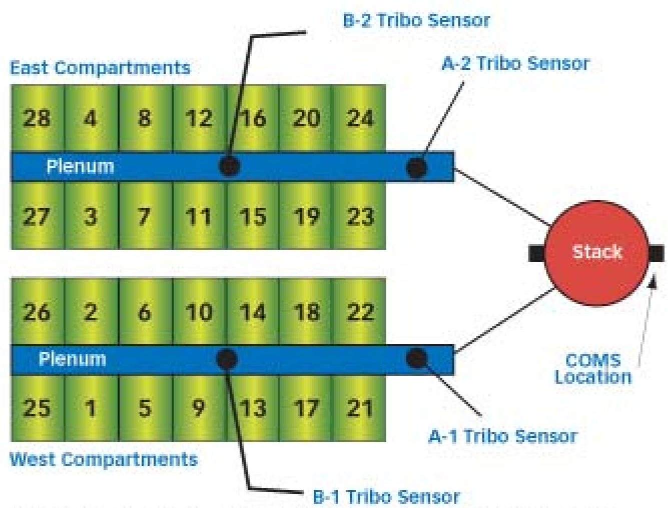
The EPA is investigating a number of initiatives designed to improve the quality of dust emission monitoring in the industrial workplace. The initiatives are of special concern to industries subject to new lower level emission maximum allowable limits (below 10 percent opacity). However, it has been shown that most, if not all, presently mandated continuous opacity monitoring systems (COMS) operate unreliably below 10 percent opacity.[1] While alternative dust emission monitoring technologies exist [e.g. continuous emissions monitors (CEMs) and triboelectric bag leak detectors (BLDs)] and have been shown to operate reliably at lower emissions levels, no New Source Performance Standards (NSPS) provisions exist to permit substitution in place of COMS. Emissions monitoring technology has advanced significantly since the older standards were written, but a massive rewriting of the relevant standards would take years and require the expenditure of significant resources.

In an attempt to resolve the monitoring conflict, the EPA proposed in October 2002 to amend certain provisions of the NSPS for electric arc furnaces (EAFs). The action was taken in response to a petition by two steel industry trade associations that requested reopening the NSPS to address COMS technological problems. The petitioners pointed out that inaccurate monitoring data could cause false emissions violations reports and potential fines and sought permission to use alternative emissions monitoring equipment, specifically referring to BLDs. The EPA agreed that, "it is appropriate to provide an alternative monitoring option for EAF owners and operators who are concerned with the accuracy of measurements at levels below 10 percent opacity. In addition, we believe that bag leak detection systems, the alternative monitoring option being proposed, are a viable alternative to COMS for the purpose of monitoring the performance of baghouses."[2]

Since numerous NSPS already existed for many industries, it became obvious that rewriting every standard mandating opacity monitors would be costly and time consuming, suggesting the need for other administrative means to resolve the issue. One example presently being considered, Voluntary Superior Monitoring, could serve as an inclusive vehicle to resolve the conflict. In this case "superior monitoring" was defined as increased frequency of monitoring, improved measurement technique, and/or monitoring the pollutant of concern. Sources interested in substituting alternative technologies would be permitted to take advantage of a number of proposed incentives, including a streamlining of the rules.[3] Applicable NSPS or National Emission Standards for Hazardous Air Pollutants would be rewritten.

Triboelectric BLD compared to COMS

Several years ago, the EPA proposed fundamental standards of performance for EAF steel plants — batch-processing operations that produce carbon and alloy steel. Generally referred to as "mini-mills," these scrap metal recycling plants are equipped with single or multiple electric arc electrodes to generate enough heat to melt the scrap metal prior to processing into various steel forms. Particulate matter is produced during most of the operations and continuously operating fabric filter baghouses are typically used as gas cleaners before the cleaned air is exhausted to a stack or penthouse vent.



EAF Baghouse Compartment Configuration & Broken Bag Detector Locations.

Emissions standards for EAF plants are based on maximum allowable particulate mass emissions from the baghouse. Since quantitative monitoring of mass emissions from dust collectors is not practical, the EPA adopted relative opacity as the monitoring method of choice for most NSPS including that for EAF steel plants.

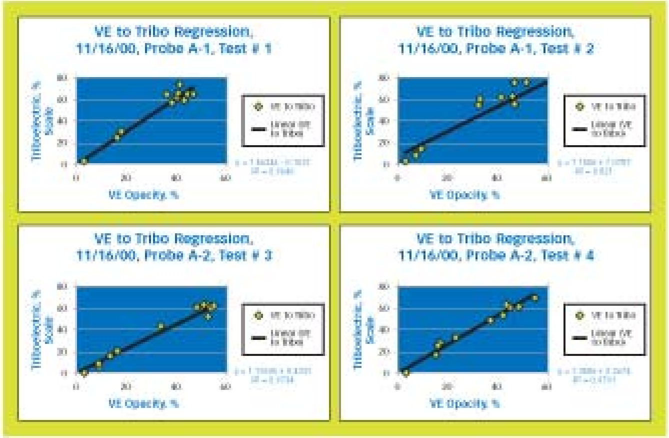
The NSPS was subsequently amended in 1984; the changes "limited visible emissions from the EAF control device to less than three percent opacity, as determined by Method 9 of 40 CFR part 60, appendix A." Additionally, the owner was required to install a COMS in the exhaust stack and report each six-minute average reading of three percent or greater as an excess emission event.

In 1999, in an attempt to resolve the dilemma, one EAF steel company applied to the EPA for permission to install a triboelectric BLD. In addition to the low level COMS limitation, they identified other troublesome COMS issues including: high maintenance requirements resulting from optical lens dust deposition; frequent misalignment problems resulting from high frequency vibration; and the inability of optical technology to localize bag failures within the baghouse. After an investigation of a variety of alternate monitoring technologies, a triboelectric bag leak detector system was chosen. EPA granted conditional approval pending performance of a forty-five day comparison to verify the relationship of triboelectric signals to opacity; the results were published in 2001.[4]

The following is, in part, a summary of their findings:

Dust collector and surrogate test set-up

Four triboelectric probes were installed within four quadrants of a negative pressure, pulse jet cleaning baghouse containing 28 compartments for comparison with the previously installed, exhaust stack mounted COMS. Testing consisted of manual injection of surrogate dust (iron oxide) and emissions tracking during two testing periods, during surrogate testing and during normal operations. A compressor injected surrogate dust into each plenum upstream of the "B" probes.



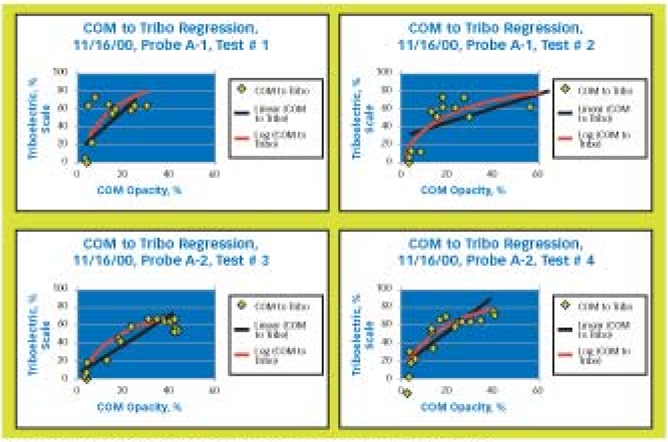
Linear Regression of VE Opacity to Triboelectric Signals, 11/16/00.

Test #1, Probe A-1 to VE:	$y = 1.5634x - 0.1031$	$R^2 = 0.9646$
Test #2, Probe A-1 to VE:	$y = 1.155x + 7.0787$	$R^2 = 0.8210$
Test #3, Probe A-2 to VE:	$y = 1.1969x + 0.4331$	$R^2 = 0.9734$
Test #4, Probe A-2 to VE:	$y = 1.358x + 2.2674$	$R^2 = 0.9791$

Comparison study discussion

Since it was unlikely opacity levels would occur above five percent, testers decided to artificially inject surrogate particulate Ferric Oxide (Fe_2O_3). During the tests the following objectives were established:

- Establish normal triboelectric signal baselines for each triboelectric sensor.
- Inject iron oxide into each plenum
- Conduct at least two tests per plenum
- Achieve at least three percent opacity as measured by the COMS and VE observer



Regression of COMS Opacity to Triboelectric Signals, 11/16/00

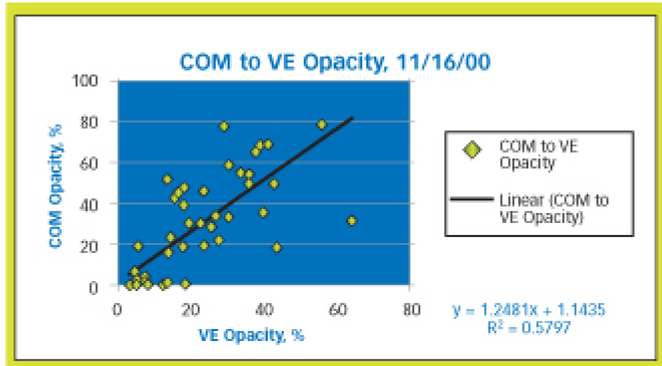
The associated R2 values are as follows:

Test #1 Probe A-1 to S:	y = 1.878x + 22.485	R2 = 0.4054
	y = 24.205Ln(x) – 7.1213	R2 = 0.5782
Test #2 Probe A-1 to S:	y = 0.7932x + 31.156	R2 = 0.3311
	y = 22.549Ln(x) – 13.203	R2 = 0.7056
Test #3 Probe A-2 to S:	y = 1.4231x + 8.8582	R2 = 0.8854
	y = 21.934Ln(x) – 17.881	R2 = 0.9282
Test #4 Probe A-2 to S:	y = 1.8411x + 13.226	R2 = 0.7561
	y = 24.875Ln(x) – 17.229	R2 = 0.9070

- Achieve up to 20 percent opacity or more

Comparison of VE opacity observations and triboelectric signals

One test performed on Nov. 16, 2000, paired the VE observations and triboelectric signal output and correlated very well for the four particulate injection periods.



Comparison of COMS Opacity to VE Opacity during Surrogate Particulate Introduction, 11/16/00

The chart below illustrates the linear regression curves of the VE opacities to the triboelectric signals on a real time basis.

The relatively high R2 values (R2 of 1.0 is a perfect correlation) for these equations indicate a very good correlation.

Comparison of COMS observations and triboelectric signals

he same probe data for the triboelectric signals is plotted against the COMS data and is plotted as both logarithmic and linear regression curves.

Figure 1

These data plot comparisons are obviously not as linear as the VE opacity comparison, exhibiting many COMS data values higher than VE opacity, which graphically demonstrates the COMS performance difficulties at dust emission levels below 10 percent opacity.

"It is clear that triboelectric signals can be correlated to opacity, and that particles of less than 1μ can be tracked by the system. Generally, the linear comparison function for triboelectric signals to opacity data is most directly applicable for opacities below 40 percent. This correlation range presents no problem for the EAF baghouse operations, which must comply with a three percent opacity standard. The TRIBO.link™ system provides a more precise and proactive tool for baghouse operators to maintain compliance with the 'no visible emission' standard imposed by the three percent opacity level."[4]

Additional performance factor

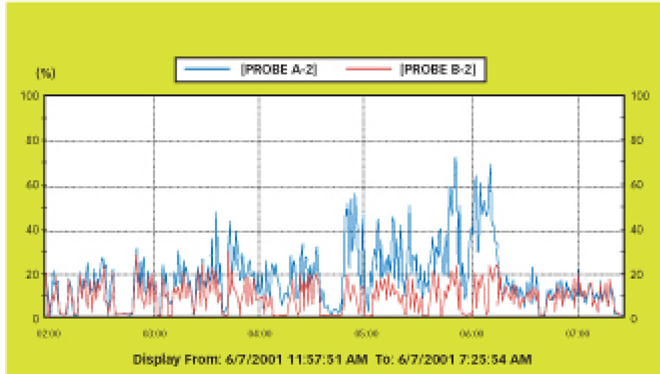


Figure 2

Triboelectric Bag Leak Detectors are usually located within the dust collector, rather than in the exhaust stack, making it possible to isolate and locate failing filter sections or individual bag filter rows (depending on the number of probes installed). In this case, four probes were strategically located within each plenum, the "B" probes upstream of the "A" probes. On June 7, at approximately 6:00 AM, an operator noticed abnormally high cleaning pulse emissions at probe "A-2" (**Figure 1**). By switching to another screen (**Figure 2**), simultaneously displaying probes "A-2" and "B-2," he quickly isolated the deteriorating baghouse quadrant, well before catastrophic failure, alerting maintenance personnel to schedule inspection and repair at a time convenient for the operation and avoiding unscheduled plant shutdown and costly fines.

Conclusion

For more than 20 years, triboelectric bag leak detectors have been utilized primarily as a maintenance management tool to identify the onset and location of impending filter failures well before the onset of catastrophic and costly breakdowns. In recent years, lower emissions standards have been promulgated below 10 percent opacity and most, if not all, continuous opacity monitors perform unreliably below that level. Consequently, federal and state regulators are expressing more interest in the triboelectric alternative as opposed to light absorbing COMS. Until now, opacity meters have been exclusively specified as emissions monitors for compliance purposes when continuous monitoring is required, resulting in a serious dilemma for industries subject to newer "no visible emissions" standards. In response, several steel industry trade organizations petitioned the EPA for permission to substitute triboelectric bag leak detectors. The EPA agrees that COMS have operating difficulties when applied to low-level emissions applications and has introduced several initiatives designed to address the problem.

As of the date of this writing the issue remains unresolved. ***PE***

Sidebar: Triboelectric bag leak detection

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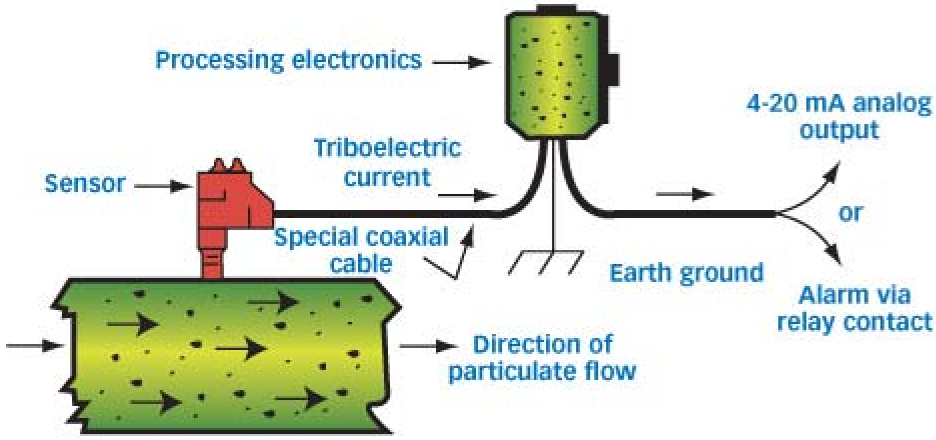

the triboelectric effect

Static electrification is a familiar phenomenon. Not so commonly known is the reason why materials become statically charged. The charging mechanism is the principle of triboelectric measurement. Static electrification depends upon an excess or imbalance of electrical charge, which may be produced by the transfer of charge when two materials are brought together and then separated or rubbed together. This phenomenon is referred to as the triboelectric effect.[3]

A sensor is usually inserted into a dust collector clean air exhaust stream (see below) extending approximately one half the diameter of the duct. Conveyed particles in the gas stream collide with the electrically isolated probe initiating the triboelectric effect (charge transfer caused by particle impaction or friction) resulting in current flow to the measurement circuit where it is amplified and filtered to eliminate unwanted electrical noise caused by nearby AC equipment. The very low level charge transfer (picoamps) is continuous and reflects a rise or fall of particulate activity forming the basis for monitoring the effectiveness of the filter system. The measured current is directly proportional to the concentration of particulate under constant conditions and can be reliably used to indicate alarm conditions or to provide data that can be analyzed to determine long-term baseline performance. As the current flows through the earth grounded circuit it dissipates harmlessly and safely. Minimum particulate flow detection limits of BLD are well below those of COMS.

References

- 1. "ASTM D6216-98, Standard Practice for Opacity Monitor Manufacturers to Certify Conformance with Design and Performance Specifications," ASTM International, West Conshohocken, Pa., 1998.
- 2. "Standards of Performance for Steel Plants: Electric Arc Furnaces Constructed After October 21, 1974, and On or Before August 17, 1983; and Standards of Performance for Steel Plants: Electric Arc Furnaces and Argon-Oxygen Decarburization Vessels Constructed After August 17, 1983," Federal Register, October 16, 2002
- 3. U.S. EPA "Superior Voluntary Monitoring," /www.epa.gov/ttn/emc/voluntarysuperior.html
- 4. J. C. Wesselman, C.W.Askins, "Comparison of Continuous Opacity Monitor and Method 9 Observations to Triboelectric Broken Bag Detector Signals on an EAF Baghouse," AISE Steel Technology, pp 53-64, April 2002