WPCA NEWS

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ISSUE 6 - 2004

WORLDWIDE POLLUTION CONTROL ASSOCIATION

Go with the Flow

Optimizing ESP Performance Via Flow Modifications

By Robert G. Mudry, P.E., Airflow Sciences Corp.

Since particulate emissions are a major concern at most industrial facilities, many plants are seeking to optimize their particulate capture equipment in a cost-effective manner. Whether the system involves an electrostatic precipitator (ESP), a fabric filter baghouse, or inertial separators, the capture efficiency can be significantly influenced by the flow patterns within the device.

In an optimization project for a coal-fired (eastern bituminous coal) power plant in the Southeast United States, the goal was to examine flow patterns within a Joy hotside ESP with SCA of 260 and develop design improvements to enhance ash particle capture. The ESP geometry is shown in Figure 1. Because of the large expansion in the vertical inlet duct, too much flow entered the middle region of the ash collection zone. The high flow velocities overloaded the collection system in that region. The outboard sections were starved of flow and thus under-utilized for ash capture. A computational fluid dynamics (CFD) model was used to prove this phenomenon; it shows how the flow does not properly expand in the inlet duct. There is a high concentration of flow in the center of the duct (red regions). *continued on page 6*

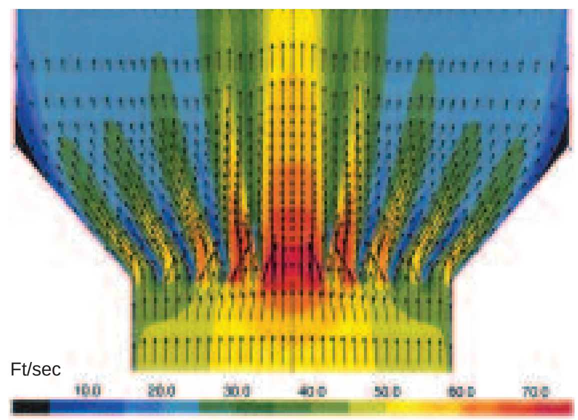

Figure 1: **Velocity pattern in ESP inlet duct**

Clean Up Your Act!

ESP Dirty Inspection Protocol

By Hank Kowalczyk, EPSCO International Ltd.

Maintenance personnel involved in internal inspections of ESPs are often knowledgeable about the objectives of a clean inspection, but seemed uncertain about the procedures and protocol appropriate for an effective dirty inspection. More specifically, their uncertainties relate to the stepped events which should be controlled from the standpoint of shutting down and de-energizing the equipment.

Because this hesitancy or confusion has frequently been observed EPSCO International feels it might be useful to identify both the stepped procedure and logic associated with an effective dirty inspection. These recommendations were documented by the late Phil Crommelin in 1999. In order to properly perform a precipitator dirty inspection which will produce the most meaningful results, certain preparations must be made.

❶ **Take an up-to-date set of electrical data.** Do this on the precipitator rectifier controls including a set of V-I readings on each set. Be sure to identify the corona starting voltage, the secondary voltage at which current just starts to flow. This should be done just before shutdown procedures begin. Examination of this data will indicate poorly operating areas, the ones where the inspections, both clean and dirty, should begin.
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Inside

Why We Do What We Do

Management and Control of an Inhibited Oxidation Scrubber.

Bruce Salisbury, PE, APS

After many years of operation of SO_2 control devices, it has become apparent that there is a need for a management philosophy that extends beyond control points, and operational instruction. A philosophy of WHY we do what we do. This is an attempt to put that philosophy on paper.

Inhibited oxidation is one of the two directions utilities moved into when we finally realized in the 1980's that we all, as an industry were lousy at running scrubbers. An industry epiphany was that you could successfully run a scrubber in a forced oxidation mode, or an inhibited oxidation mode, but could not successfully operate a scrubber at equilibrium. Equilibrium was a condition that lead to scaling, pluggage, under-deposit corrosion, and a series of nightmares experienced by utilities in the 1970's and 1980's. This author does not attempt to persuade the reader that one end of the equation is superior to the other, merely that both ends of the equation work, and are preferable to the middle of the equation, equilibrium.

Inhibited oxidation scrubbing uses elemental sulfur, or sodium thiosulfate. In addition, with operation at a pH regime that does not generate a lot of oxidation potential. This should be measured frequently, and becomes the first indicator of the health of the system. It does bring up the first management point of the system, and that is dissolved solids. ***The first rule of this system is "clean water is not your friend".***

Dissolved solids in this process liquor, provide buffering in the system, and provide a sodium supply to allow sulfur to change to sodium thiosulfate. If you cannot maintain a medium to high dissolved solids content in this liquor, you cannot successfully inhibit oxidation. In the case of some facilities, this means that you need to recycle water to keep this dissolved solids presence in your liquor. This means you will waste less water.

Dissolved solids, is the first component of a two component system for managing thiosulfate presence and managing inhibited oxidation. The other component is the addition of a component, such as elemental sulfur or sodium thiosulfate. Increasing presence of thiosulfate can be as simple as adding more elemental sulfur. ***This leads to our second rule; "Manage dissolved solids and thiosulfate to manage inhibited oxidation potential."***

Rules of the System

1. Clean water is not your friend.
2. Manage dissolved solids and thiosulfate to manage inhibited oxidation potential.
3. Manage inhibited oxidation potential to manage solution phase magnesium presence.
4. If density and SO_2 removal are controlled, pH is controlled.
5. If density and SO_2 removal are controlled, pH is controlled.

What are we trying to accomplish by inhibiting oxidation potential? In the 1980's the answer was to prevent scale buildup and plugging of scrubbers. That has shifted in the last decade, due to the discovery that sodium thiosulfate was discovered to be one of those rarities in life where; "if a little is good, a lot is better", happened to be true. At the levels now being run in scrubbers, scale buildup and plugging are faint and distant memories. The real function of thiosulfate today is to manage solution phase magnesium presence. More thiosulfate, means more magnesium, regardless of the sorbent blend used in the scrubber. Magnesium, unlike a large, unwieldy calcium molecule, can race around a scrubber, finding SO_2 molecules, transferring them to calcium when they come into chemical contact. More magnesium increases the efficiency of the scrubber. ***This leads to our third rule; "Manage inhibited oxidation potential to manage solution phase magnesium presence".***

Almost all scrubbers have density measurement and pH measurement. It is an absolute guarantee that your personnel work on both of these systems a lot, and hate them. Control of pH as an exclusive component of SO_2 removal can lead to frustration and a lack of success. This is due to the fact that that pH is a secondary component of control, not primary. If you are controlling a scrubber by controlling pH, you are letting the tail wag the dog.

There is a solid, repeatable relationship that exists between density, pH, and SO_2 removal. It is probably the first parametric chart that should have produced for your scrubber, but chances are, does not exist. Most scrubber people would tell you that as density increases, or pH increases, SO_2 removal

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The Finishing Touch

Selection of Materials of Construction for WESP after WFGD

Dr. Boris Altshuler, Wayne P. Buckley, James Reynolds, CR Clean Air Technologies and Ron Richard, Enerfab, Inc.

The following is a summary of a paper presented at the National Association of Corrosion Engineers on August 29, 2004 in Washington DC.

New Federal and State regulations, designed to reduce emissions of sulfur dioxide (SO_2), will require many industrial and utility plants to install flue gas desulfurization systems. While wet flue gas desulfurization (WFGD) systems can achieve high removal efficiencies for SO_2, as well as other acid gases, they do little to abate sub-micron solid particles, acid aerosols or liquid droplets, which are the primary cause of a visible plume. Wet electrostatic precipitator (WESP) systems, either mounted on top of the WFGD, or installed after the WFGD, are being considered as a final polishing device to control these very small and difficult to capture particles. The proper selection of the materials of construction for the WFGD and WESP is critical to assure a reasonable service life for the equipment. The key factors that influence corrosion rates in WFGD and WESP are chloride level, temperature and pH. The composition of alloy steel, principally the percentage of chromium, nickel and molybdenum, determines that material's resistance to corrosion. Experience with corrosion in a pilot WESP at a coal-fired utility plant, burning 3% sulfur coal, was presented. The paper analyzed why corrosion appeared in the lower 316L perforated plate gas distribution section, (similar to the conditions found in a WFGD outlet), and not in the 316L WESP collector section. The different corrosion rates may be explained by passivation of the collecting tubes by a strong oxidizing agent within the WESP, either from the corona discharge that creates gas-phase chemically active radicals or oxidizing agents which are introduced or absorbed into the liquid film that covers the collection surface.

To read the full paper, go to: www.cr-cat.com/news.htm

U.S. Utilities: Come Blow Your Horn

Acoustic Cleaners Heating up the Industry!

Vince Barreto, Acoustic Product Manager, BHA Group*

The Utility Industry has been using acoustic cleaning technology since the early 1980's. The most common applications for the acoustic cleaners have been baghouses, boilers, electrostatic precipitators and selective catalytic reactors (SCR). These are areas where the ash and/or soot deposits are dry.

Acoustic Cleaners are pneumatically operated horns that produce low frequency, high-energy sound waves. The sound waves are produced when compressed air enters the sound generator and forces the only moving part, a diaphragm, to flex. The flexing action of the diaphragm generates sound waves that are amplified by the acoustic horn's bell. The resulting sound waves cause particulate deposits to resonate and dislodge from the surfaces to which they have bonded. Once dislodged, the deposits are then removed by gravity and/or gas flow.

Over the past five years, acoustic horns have received a great amount of positive exposure within the U.S. Utility Industry with the successful use of acoustic cleaners as the sole catalyst cleaning system on SCR reactors. Acoustic cleaners have proven to be effective on high dust and low dust reactors following boilers burning a variety of coals and other fuels. Experience has shown that acoustic cleaners can effectively clean all types of catalyst designs: plate, honeycomb and corrugated. The cost of purchasing and installing acoustic cleaners on new reactors is about 1/8th the cost of purchasing and installing conventional sootblowers. There are more than 80 SCR reactors fitted with acoustic cleaners in the U.S. today. The use of the acoustic cleaning on this application has saved the U.S. Utility Industry millions of dollars in construction and operating cost.

continued on next page

Figure 2: **Model D-75s Installed on a SCR Reactor**

The use of acoustic cleaning on SCR reactors has generated new enthusiasm for using acoustic cleaning on other applications within the U.S. Utility Industry as well. There is now much better industry understanding of the capabilities and benefits of using acoustic cleaning technology. More and more utility plants are using acoustic cleaners to remove ash deposits from heat transfer surfaces in the back passes of boilers and also on air preheaters. The key to success on these applications is installing the acoustic cleaners in areas of the boiler that have primarily dry ash deposits.

The experience accumulated by the U.S. Utility Industry over the past 25 years with the installation of acoustic cleaners on a wide range of applications has proven that acoustic cleaners are effective in resonating drier ash deposits and can provide significant economic benefits. This better understanding of the capabilities of acoustic cleaners has lead to more consistent and successful installations.

***Effective August 31, 2004, GE Energy has acquired BHA Group**

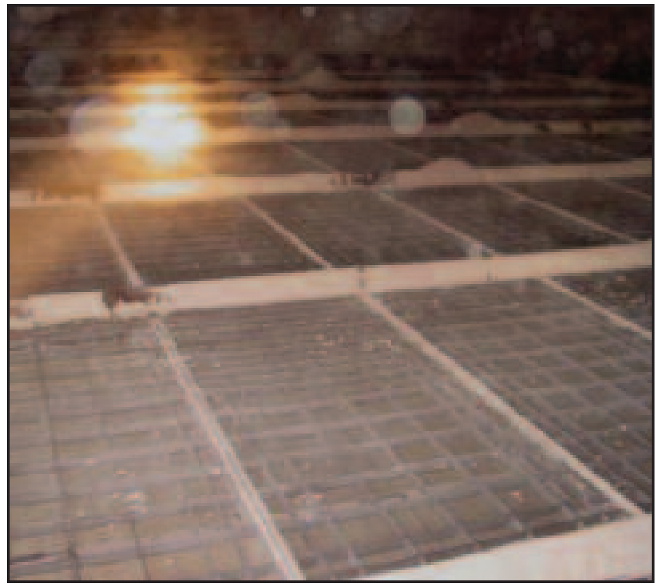

Figure 3: **A View Inside a SCR Reactor that is being cleaned solely by acoustic cleaners.**

Art? Science? Skill?

What Does it Take to Read TR Controls System Meters

By Paul Ford and Peter Aa, Redkoh Industries

How do you rate as a meter reader!

Interpretation of the needle position on a TR control meter has a lot more to do with the fundamentals of electricity than it does with the operation of the precipitator. Drawing conclusions from the meter needle positions is more to do with the operation of the precipitator than it does the understanding of electricity.

Confused? Let try to clear up some of the confusion.

First of all, we need to understand what the meters mean!

- The Voltmeter reads the voltage being delivered to the primary of the transformer rectifier (TR) by the silicon controlled rectifier (SCR) controller.
- The Amp meter reads the current being drawn from the plant electricity supply.
- The Kilovolt meter reads the voltage that has reached the precipitator high voltage grid.
- The Milliamp meter reads the current that is being drawn by the precipitator high voltage grid.

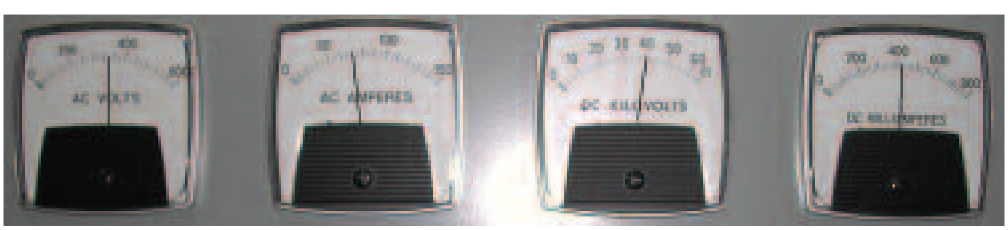

Figure 4: **Typical Meters**

Lets look at some possibilities.

Figure 4 shows four meters. These meters are typical of meters installed on transformer rectifier control cabinets. The scales are somewhat academic since the chance of you having this combination of meter scales is not high. The readings on Figure 4 are considered good and seeing this, you would probably walk on by. However the readings on the next group, Figure 5, should raise some suspicion that there is a problem and you would most likely want to look at this in more detail.

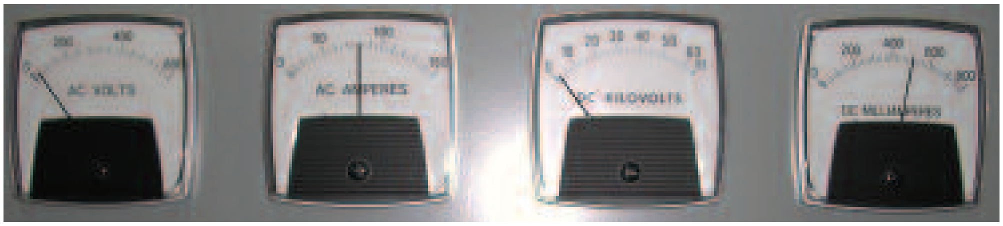

Figure 5: **Electrical Short Circuit**

Indication

In Figure 5, electrical meters indicate very low primary volts (AC volts) while at the same time indicate rated or very high primary current (AC amps) and secondary currents (DC milliamps).

Probable Cause

This electrical condition is usually caused by an electrical short or high resistance ground inside the precipitator or bus duct. Electrical shorts and high resistance grounds can be caused by any of the following:

- Full hopper.
- One or more broken discharge electrodes contacting a grounded surface.
- Particulate buildup that bridges between one or more discharge and collecting electrodes.
- Particulate buildup that bridges between the shell wall, or roof, and any high voltage component.
- Electrical tracking across the surface of a support, anti-sway, wall, or post insulator.
- A ground condition inside the transformer rectifier tank.
- Scale/rust bridging the center conductor of the bus duct and the duct wall.

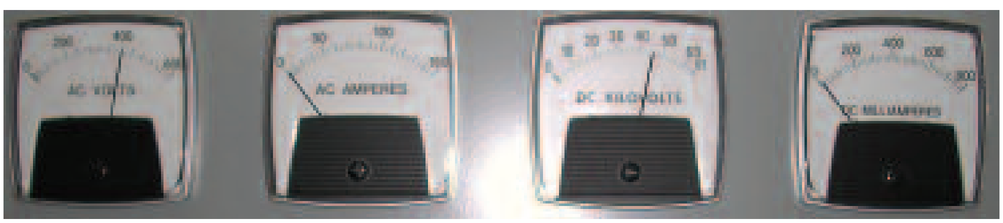

Figure 6: **Electrical Open Circuit**

Meter readings that indicate the opposite of a short circuit (Figure 5) are shown in Figure 6.

Indication

Primary and secondary voltage are at maximum transformer rating while the primary and secondary current are at zero. The spark rate will be zero (if sparking does occur, start by checking clearances in the high voltage bus duct).

Probable Cause

The cause of these readings is an open circuit on the secondary of the transformer rectifier set. An open circuit can be caused by any of the following:

- The electrical lead that connects the support insulator to the high voltage pipe and guard bus system has become disconnected but is NOT touching ground.
- The electrical conductor inside the high voltage pipe and guard bus system has separated but is NOT touching ground.
- The connector between the TR output bushing and the pipe and guard bus system is disconnected at one end and is NOT touching ground.
- An open circuit has occurred inside the TR tank. The most likely causes are an open in the secondary winding of the transformer coil, an open choke, or a rectifier stack that has an open circuit or has fallen out of its mount and become disconnected.

Redkoh has a collection of ten different meter readings that indicate a precipitator or electrical problem. Contact Redkoh for a free copy.

Go with the Flow *continued from front page*

Plant personnel had several concerns:

- ESP performance was marginal, with opacity (a measure of particulate emissions) running 16-19%.
- Operating so close to their 20% opacity limit occasionally forced the plant to curtail electricity output.
- ESP performance was noted to degrade over time, requiring the entire 300 MW unit to be shut down every 50-60 days to wash the ESP.

Figure 7: **Final design flow distribution baffles**

Airflow Sciences Corporation (ASC) was contracted by the utility to improve the flow patterns through the ESP. A testing program was developed that utilized a vane anemometer probe to measure the velocity profile entering the ESP. Test engineers performed baseline flow measurements and devised a new arrangement of flow control devices (vanes and baffles) within the inlet duct to generate a more uniform flow pattern at the ESP.

Initially, ASC personnel installed prototype flow devices made of wood. This allowed for rapid modification and adjustment to tweak the flow patterns. The velocity profile was re-tested, and the necessary adjustments to the flow control devices were made. After six iterations, the velocity profile at the ESP was within industry standards. The final design of prototype wooden baffles (Figure 7) was then replaced with welded steel plate in the same configuration.

After the unit came back online, ESP performance improved dramatically (Figure 8). The opacity was consistently less than 10%. Thus, the plant can now operate at the full electricity output at a lower emissions rate than prior to the modifications. Also, the ESP operated for a full year without any washes. This reduced unit downtime and eliminated five costly washes per year.

ESP Performance - Before and After Modifications

	Before	After
Inlet Flow Uniformity (RMS Deviation from Avg. Velocity)	27.8%	11.9%
Full Load Opacity	16–19%	<10%
Unit Derates Due to Opacity	~10 MW	None
ESP Wash Frequency	50-60 Days	350 Days

Figure 8: **Summary of ESP performance**

Why We Do What We Do *continued from page 2*

would increase. Density increases removal rate by adding more surface area to a scrubber for chemical reactions to take place, and pH increases removal rate by adding alkalinity to the scrubber when pH goes up. What makes density a more useful control than pH is the ability to swing it over a large range, without harm to the system. This is not something that cannot be said for pH.

Too low a pH generates a higher oxidation potential in the system, leading to the formation of sulfate scale. A pH that is too high can lead to the formation of carbonate scale. This narrow range of desirable pH leads one to the conclusion that you do not want to control pH, (in the context that you want to move it about), but that you want its position fixed. The only way to accomplish this is by controlling density. Instead of raising pH, raise density. Instead of lowering pH, lower density. By doing this, pH never moves, contributing to more reliable scrubber operation. ***This leads to the fourth rule; "If density and SO_2 removal are controlled, pH is controlled." This also leads us into the fifth, and final rule; "If density and SO_2 removal are controlled, pH is controlled."***

By managing these rules, in descending order, your scrubber will be able to give you levels of performance you never imagined, requiring less maintenance and even less attention from your operations personnel, not more.

Clean Up Your Act! *continued from front page*

❷ **Observe the proper shutdown procedure.** As soon as the coal mills are stopped and/or coal is taken out of the unit or other particulate generating activity stops, shut off the rappers.

➔Leave the rectifiers in service until the fans, forced and induced draft, are shut down.

➔Only after fans are down shut off rectifiers, lock them out and proceed through the interlock system to prepare for opening the doors.

➔Move the inspection equipment up to the selected access door, don protective gear and open the door slowly and carefully. Be careful of hot dust; have camera ready.

➔Attach portable ground and enter precipitator disturbing as little as possible.

Figure 9: **Donut type deposits on discharge electrodes**

❸ **Make a detailed inspection.** Caution: Be careful of deep dust deposits. The surface may be cool, but the interior may retain sufficient heat to cause burns. This is especially true in hot (over 450 degrees F) units.

➔Deposits not compacted by electrostatic forces tend to be quite fragile. Make observations on perforated plates, flue and nozzle floors, turning vanes flue struts and hopper corners before the evidence is dissipated. Use cameras.

➔After making general observations as above, begin a duct by duct precipitator inspection noting the depth of deposits on plates and their character (light and fluffy, compacted, muddy, cementaceous, etc). Examine discharge electrodes and note diameter and character as above as well as nature (donuts, smooth, pointy, etc). Note if deposits are confined to certain wires or plates to certain sectors (outboard, inboard, 8th through 12th plate, etc).

➔If time permits, examine sectors with heavy deposits to determine if plates are jammed in spacers, stuck against walkways, rapper bars are broken, welds failed, etc. If time does not permit, note areas for special attention during clean inspection.

➔Inspect insulators (rapper, support and anti-sway) for evidence of tracking, moisture and carbon deposition. Often this is better seen when dirty.

➔Inspect insulator compartments and bus ducts for evidence of inadequate purging, or poor boiler draft control. Look for water in-leakage.

➔In flues or precipitator casings, particularly in corners and under roof, look for evidence of water leakage or air infiltration.

➔In measuring dust deposits, use your ruler. Measure - don't guess.

➔Always look down into hoppers in an attempt to locate build-ups in corners where grounding or clinkering has occurred.

❹ **The best way to explain is with a photograph.** When taking photographs, keep in mind that you will be showing what you have seen to people who have no intention of going into a dirty precipitator. We have had good luck with an underwater camera, auto focus and flash using Kodak Gold 400 film.

❺ **Interpret results by providing a roadmap for the clean inspector to follow.** To aide in interpretation you should mark results on a plan view of each precipitator section. Then mark rapper locations and rapper anvils on this drawing. Indicate any stuck plates or bound spacers.

➔You can then locate non-functioning rappers, broken rapper bars, etc. A clean section may indicate a disconnected or grounded power supply or a grounded insulator.

➔Sketching the deposits in flues or on perforated plates can show gas distribution problems.

➔Observation of dust deposits on electrodes can be confirmed by a review of electrical operation history. Discharge electrode deposits are usually manifested by rising voltage and falling current while collecting electrode build-ups are often manifested by falling voltage and current.

➔Donut type deposits on discharge electrodes are normally less destructive than a uniform smooth deposit on discharge electrodes.

➔Heavy build-ups in one sector of a field with the other sector being clean always have a bad effect since they disrupt electrical fields.

Following the above procedure, making accurate and complete notes, and drawing sketches to locate suspected problem areas, will assure an effective dirty ESP inspection, and serve to provide guidance for the next step; an effective clean inspection.

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