WPCA NEWS

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WORLDWIDE POLLUTION CONTROL ASSOCIATION

Plasma Enhanced ESP Technology for Mercury Control

John Montgomery & Dan Battleson, MSE-Technology Applications, Butte, Mt.
Boris Altshuler, Wayne Buckley and Isaac Ray, Croll-Reynolds Clean Air Technologies

In December 2000, the U.S. Environmental Protection Agency announced that mercury emissions from coal-fired power plants would be regulated to reduce the health risks posed on humans and the environment. The proposed regulatory limits are scheduled be promulgated in December 2003, with final compliance expected by December 2007. Anticipated regulations are expected to require 60% to 90% reductions in mercury emissions.

A major problem in controlling mercury emissions is the low ratio of oxidized mercury to elemental mercury within the flue gas. Wet flue gas desulfurization systems used to abate acid gas emissions can efficiently remove water-soluble mercury compounds and mercury adsorbed onto particulate matter. However, the elemental mercury removal efficiency of these systems is typically less than 1%. In a recent power plant study, mercury emissions average a 60/40 split in elemental versus oxidized mercury and is largely dependent on the type of coal being burned in the process. Typically, mercury emissions generated by burning eastern bituminous coal are 60% to 80% in the oxidized state. Comparably, emissions from western sub-bituminous and lignite coals, because of their inherent low sulfur and chlorine content, are only 10% to 20% in the oxidized state.

To address the problem of controlling mercury emissions, MSE Technology Applications, Inc. and Croll-Reynolds Clean Air Technologies, Inc. teamed to develop an innovative technology that applies plasma physics to a wet electrostatic precipitator, creating a plasma-enhanced electrostatic precipitator (PEESP) technology. Test results from a proof-of-concept test campaign clearly showed the PEESP technology was capable of oxidizing elemental mercury vapor in a process gas comprised of dry air and trace quantities of elemental mercury. However, the test results using a simulated flue gas containing nitrogen oxide (NO) and sulfur dioxide (SO_2), as well as trace amounts of elemental mercury showed a significant reduction in the mercury oxidation efficiency. Upon further investigation, it was concluded that NO,

Continued on page 3

INSIDE HIGHLIGHTS

How a Fuel Change Led to Improved Baghouse Performance (and Lower Energy Costs)

by Jake Shelton - BHA

A coal-fired power plant in Alaska made the decision to burn waste coal in their Unit 1 boiler. A series of tests indicated that since the coal had a lower Btu value, more of it would need to be burned, tripling the dust loading to the reverse air baghouse. The excessive amount of flyash, coupled with the already high baghouse pressure drops was limiting steam production (down to 92% of design capacity). The plant increased the horsepower of the ID fan from 600 to 900, but the baghouse pressure drop was still a problem, even after all new fiberglass filter bags were installed. One problem was that the filters were blinding (particulate was becoming embedded within the fabric) and the reverse air cleaning cycle ran almost continuously. Regardless of how much the bags were cleaned, the average pressure drop remained at 9-10" w.c. .

In October 1999, the plant decided to replace their standard fiberglass filter bags with ePTFE membrane filters A major advantage of using membrane filters is that flyash collects on the surface of the membrane, not within the bag fabric. This helps to eliminate blinding problems, and allows baghouses to operate with a decrease in operating differential pressure.

In addition to the membrane filters, several acoustic cleaners were also installed in the baghouse. The acoustic cleaners were intended to further improve the cleaning of the membrane filters.

Figure 1 - Acustic Cleaner

Acoustic cleaners emit low frequency high energy sound waves that create vibra-

Continued on page 5

REBUILDING AND UPGRADING ELECTROSTATIC PRECIPITATORS - A CONSULTANT'S PERSPECTIVE

by Bob Hall & Hank Kowalczyk - EPSCO International, Ltd.

Many users are looking for ways to rebuild and upgrade their existing equipment in the most cost-effective way, with new, more stringent pollution control regulations, and the high cost of new pollution control equipment. Sometimes process or fuel changes result in increased emissions that must be reduced to maintain compliance with current regulations.

Over the past ten years, electrostatic precipitator (ESP) rebuilds with performance upgrades have become a popular alternative to ESP replacement as a way of reducing particulate emissions. Where conditions permit, rebuilding and upgrading an ESP can result in significant cost savings over complete replacement with totally new systems. This article identifies cost-effective rebuild and upgrade options available to the ESP user to enhance precipitator performance and maintain compliance with all pollution control regulations.

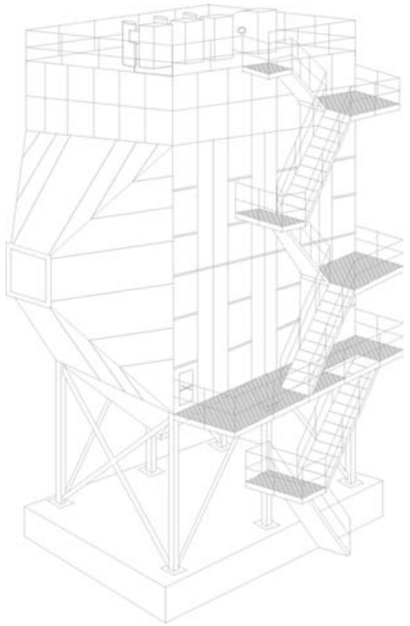

Figure 2 - ESP Model

REBUILD AND UPGRADE OPTIONS

There are many options available to rebuild and upgrade an ESP to improve its efficiency and reduce emissions. Some combination of the following options would likely be used to upgrade an ESP on any application including: boiler/process modifications; gas/particulate conditioning; additional collecting electrode (CE) surface area; increased field height and/or electrical sectionalization; modified CE spacing and discharge electrode (DE) geometry; reduce air infiltration; minimize heat loss; modify gas distribution; modify rappers and controls; match power supplies to loads; upgrade AVC controls and auxiliary equipment, such as pressurization systems and hopper level alarms.

REBUILD AND UPGRADE EXAMPLE

The best rebuild and upgrade options are site specific. Any combination of the above modifications can be made, based on technical and economic considerations.

The following is an example of a hypothetical, but somewhat typical case. Consider a three-field ESP of rigid frame design operating on a coal fired boiler. Efficiency is about 97%. The flue gas temperature is 340° F and the fly ash has high resistivity. The ESP casing is in good condition and corrosion is not a problem. ESP efficiency must be increased due to a change in the coal supply. The following actions may be recommended:

- air heater modifications to produce an ESP inlet temperature of 270° F.;
- gas distribution is improved and maintained by rapping inlet distribution screens and eliminating build up in the bottom of the inlet nozzle; increase of 20% in collecting plate area with retrofit of RDE technology, using large areas between fields;
- increase collecting plate area by an additional 20% by raising the roof and increasing the plate height;
- new RDE internals form six electrical fields in the direction of gas flow compared to the original three; rebuild the first two fields with 12" plate spacing and very aggressive RDEs;
- rebuild the last four fields with 16" plate spacing with less aggressive RDEs to promote higher voltages and electrical field strengths;
- use gravity impact rappers to reduce re-entrainment; install modern electrical energization equipment, especially microprocessor-based controls;
- eliminate air infiltration and heat loss as required.

It is not hard to visualize that the above modifications could improve ESP efficiency to 99.5% from its original 97%. The efficiency increase could be even greater if the ESP to be rebuilt is in poor condition.

Rebuilding and upgrading an existing ESP can be a cost effective alternative to increasing the casing of an existing ESP, building a completely new ESP, or installing a fabric filter. This is particularly true of rebuilding and upgrading rigid frame ESPs with rigid discharge electrode technology. Savings can arise from the reuse of foundations, support steel, nozzles, ductwork, casing, hoppers, ash handling equipment, access, and insulation and lagging. The above rebuild and upgrade techniques are proven technologies that have already been successfully used worldwide.

A key to rebuild and upgrade technology is the ability to predict the performance of the modified equipment with a high degree of confidence. This is not a task for the inexperienced. With extensive theoretical understanding of ESPs, a good database of experience, and specialized modeling capabilities, the performance improvement can be predicted with the high degree of confidence necessary to make this a viable option to more costly alternatives.

The independent consultant can provide an objective assessment of the users requirements, keeping in mind his clients preferences and financial resources. Often the existing electrostatic precipitator (ESP) can be rebuilt and upgraded at a fraction of the cost of new equipment, and yet, efficiency can be increased sufficiently to meet the emission limitations.

EPSCO

Croll-Reynolds - continued from page 1

and to a lesser extent SO_2, reduced the concentration of reactive species though competing reactions, thus lowering the mercury oxidation efficiency of the process. Since NO and SO_2 are always present in flue gas and in much higher concentrations than elemental mercury, it may prove difficult to achieve a high degree of mercury oxidation without either first removing most of the NO and SO_2 from the flue gas or identifying a mercury selective reagent.

In the current test campaign, partially funded by the Electric Power Research Institute, the primary objective was to identify and demonstrate various reagent gases that when passed through a corona discharge would produce selective chemical reactions in the flue gas. In particular, reagent gases were sought that would:

- oxidize elemental mercury without affecting the oxidation states of NO and SO_2
- oxidize NO to nitrogen dioxide (NO_2) without affecting the oxidation states of SO_2 and elemental mercury
- oxidize SO_2 to sulfur trioxide (SO_3) without affecting the oxidation states of NO and elemental mercury.

Selected reagents were used and mercury oxidation efficiency of the 1-scfm PEESP test cell averaged 43% with the central electrode energized to a power density of 3 W/cfm. Although not fully understood, it was experimentally demonstrated that SO_2 within a saturated flue gas caused a reduction in mercury oxidation efficiency. Experiments were also conducted under dry simulated gas injected with a selected reagent. Based on inlet and outlet elemental mercury concentration, the mercury oxidation efficiency of the 1-scfm test cell averaged 79% under the dry test conditions.

In the oxides of nitrogen (NOx) reduction experiments, it was shown that ozone generated by the PEESP electrode effectively oxidized NO to NO_2. With the central electrode at a nominal power density of 3 W/cfm, the NOx removal efficiency of the PEESP technology varied between 3% and 6%. By increasing the electrode power density to 10 W/cfm, the NOx removal efficiency increased to an average 15%. The addition of a selected reagent to the process gas further increased the NOx removal efficiency to 22%.

Using another reagent, the reaction mechanism for NOx reduction was changed from an oxidation process to a reducing process. In this configuration, NO is reduced to nitrogen and oxygen. The NOx removal efficiency of the PEESP system under this test scheme measured up 36% at a power density of 10 W/cfm. By increasing the residence time of the flue gas through the PEESP system, it is possible to achieve high reduction efficiencies.

The SO_2 reduction experiments showed that in a saturated process gas approximately 8% of the total SO_2 was absorbed by the condensing vapor. The addition of 1,200 ppmv of a selected reagent to the process gas reduced 99.8% of the SO_2. In effect, the PEESP technology under this test condition was functioning as a flue gas desulfurization system.

Based on these test results, the PEESP technology has the potential to be developed into a full scale mercury abatement system operating within a wet ESP. The benefits of such a technology include lower cost, pressure drop, reduced space, and eliminates the need for carbon injection and baghouse collection with its associated disposal issues. The mercury collected in the PEESP system is captured within the liquid slurry on the wet ESP collection surfaces where it can be further concentrated by recycle through commercially available water treatment systems. Further demonstration testing needs to be conducted on actual coal-fired flue gas. The Electric Power Research Institute has issued a contract to Croll-Reynolds to build a 5,000 acfm pilot wet ESP with Southern Company's Alabama Power's Plant Miller acting as host during the fall of 2003 that incorporates the PEESP technology.

Analog vs. Digital Meters on Your TR Controls! The Debate Continues!

By Paul Ford & Peter Aa - Redkoh Industries

This article has been written by two people, both with extensive precipitator backgrounds and both with widely different opinions with respect to the need for metering requirements.

For those of you who are faced with the decision of using either analog or digital meters, or a combination of the two, to display readings on the front panel of your TR controls cabinets we offer the following arguments.

In general, the readings we are interested in are primary and secondary voltage and current, Spark data, Arc Data and Power consumption levels.

Since the choice of display methods is usually decided by the end user, and not the control supplier, here are a few issues that should be considered when specifying meter type.

Opinion 1

Analog meters have long been the standard for viewing and manually recording electrical levels from various pieces of electrical equipment on precipitators. For the most part they are being replaced and or supplemented with digital readouts.

There seems to be some mystical love affair between precipitator operators and analog meters. Perhaps it is because they are unaware of the additional accuracy that digital readouts offer.

The rhetoric about liking to watch the swing on the meters to judge the operation of a TR and its control is very simplistic compared to the many ways the data can be displayed on a digital screen or a computer screen. Having digital values available allows operators to manipulate the data into visual representations (line, bar, or pie charts for instance) of precipitator electrical consumption.

One of the big advantages of a digital metering system like figure 3 is that they can be averaged to provide a more realistic representation of actual precipitator energization.

Figure 3 - Digital Meter

Continued on page 5

Reducing Plant Emissions and Operating Costs

by Rob Mudry - Airflow Sciences

Recently, a southeast U.S. electric utility was working to improve the efficiency of its particle collection equipment. Their 440 MW coal-fired power plant utilizes an electrostatic precipitator (ESP) to collect flyash and minimize stack particulate emissions. The plant was seeking a cost-effective way to improve ash capture in the ESP in an effort to avoid additional capital expenditures.

It was suspected that the gas velocity patterns within the ESP were sub-optimal. If gas velocities are too high in certain areas, the ash momentum carries it through the ESP too quickly for it to be captured by electrostatic forces. As a first phase in the analysis, the utility had on-site testing performed to measure the flow patterns within the ESP. This was completed during a 1-day test period at the end of a plant outage.

The testing revealed that the flow profiles within the ash collection zone were far outside of industry standards. This led to Phase 2 of the project: flow modeling. A Computational Fluid Dynamics (CFD) model of the ESP was created. This model was then used to simulate the flow within the ESP and to develop an improved design.

The baseline flow model, representing current operating conditions, indicated the same sub-optimal gas flow profiles as the field test. One plot of the CFD results is shown in Figure 5. Very high gas velocities, in excess of 8 ft/s (2.4 m/s) exist along the top and bottom regions of the ESP. This highly non-uniform flow profile degrades the ESP ash capture efficiency.

The recommended modifications were installed in the ESP. When the unit returned to full load operation, two significant performance improvements were noted:

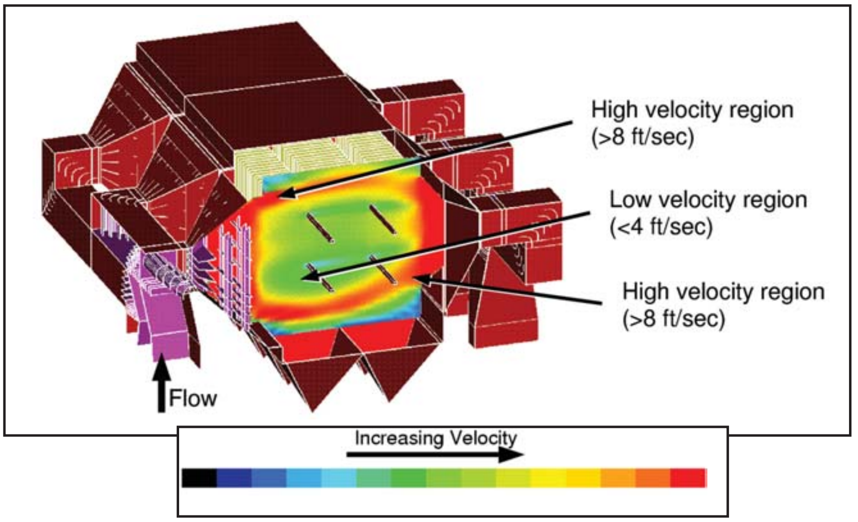

Figure 5 - Baseline flow patterns through ESP

Engineers used the flow model to develop the necessary flow control devices to optimize the ESP velocity profiles. These flow control devices included turning vanes, baffles, and perforated plates that direct the flow properly within the ESP while resulting in minimum system pressure loss.

1. Opacity (a measure of particulate emissions) dropped from 18% to 7%.
2. Gas conditioning via chemical injection of sulfur trioxide (SO_3) is not required anymore to achieve this opacity reduction.(Figure 4)

Utility personnel are highly pleased with the environmental impact of reduced particulate emissions. Further, the plant estimates a cost savings of $80,000 per year due to elimination of the SO_3 injection.

ESP Performance Before and After Modifications

	Before	After
Opacity	18%	7%
SO_3 Injection	8 ppm	None
Annual SO_3 Operating Cost	$80,000	$0

Figure 4

Airflow Sciences Corporation

BHA - continued from page 1

tions to dislodge particulate deposits from surfaces. The sound waves are powerful enough to break apart heavy particulate concentrations, but do not damage surfaces. In this application, the acoustic cleaners are only sounded for 10-20 seconds every 1-2 hours.

Figure 6 - Acoustic cleaner installed

The acoustic cleaners have worked so well that the reverse air (cleaning) fan has basically been shut off. It is only used once a week to remove any remaining particulate on the filters and to keep the fan in good working order. This has resulted in tremendous energy savings.

The average pressure drop is now about 7" w.c., but with more frequent sounding of the horns, it could be reduced to 5" w.c. By using acoustic cleaning instead of reverse air cleaning, bag life has also been extended significantly. The membrane bags were installed in 1999 and are still in service. But possibly the most critical result is that steam production is now back to 100% and opacity is well within target range.

The interesting twist to this story is that the plant's primary goal was to lower fuel costs, but they ended up lowering energy costs and particulate emissions as well.

Redkoh - continued from page 3

Screens can be locked allowing data to be viewed in a static fashion. Meters that are bouncing around due to sparking and arcing provide almost no useful data regarding the usable power in the precipitator. Pre-spark reading with data locked at the values that were achieved just prior to the last spark can also be viewed with digital displays.

The maximum current level during a meter swing is often interpreted as the operating level, when in fact it may represent the current being drawn as a result of a spark or arc. The average value that can be given by the digital meters is more indicative of power used for collection over a running average of time.

Opinion 2

Analog Meters like figure 7 are the most fundamental and reliable method of establishing the well being of the precipitator. They require very little in the way of background circuitry to provide accurate and consistent readings.

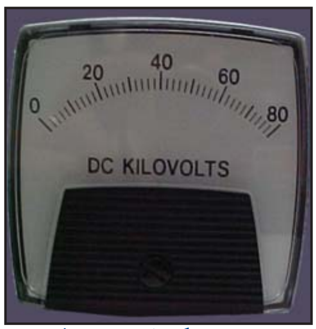

Figure 7 - Analog Meter

They are typically easy to read and require low concentration levels to pick out badly operating fields and require only a cursory glance to establish operational comfort levels.

As a "tuning" aid analog meters are indispensable and allow verification of smooth and controlled operation of any precipitator field. Sparks and Arcs can be easily seen as they occur. The intensity of the flicking needles is representative of the controls responses.

Short-term operational strategies are easily seen, with phase backs and ramps being clear from the meters' response. Excessive spark rates and control's inadequacies are quickly determined. Changes to strategies are easily observed.

It is true that some of these capabilities require an experienced eye.

Digital Meters only display data after a certain amount of number crunching, leaving avenues open for abuse. Data may be over-processed and not true information. Screen updates are presented in the way that the design engineer chooses rather than the way that the precipitator operates. Digital data, more often than not, disagrees with other available analog data and creates confusion because of the discrepancies, usually caused by true RMS vs. average values.

Tuning requires the digital data to be trended in an effort to establish the controls effectiveness.

Believing digital information relies heavily on the confidence of the controls' capabilities.

Having been through this, there is little doubt that the best method is to combine digital and analog information in an effort to gain the best of both worlds.

There is no disputing that a controls ability to obtain digital data for the purposes of recording, and allowing computers to manipulate the data into visual representations of precipitator electrical consumption is desirable.

Bar graphs of current or voltage levels arranged from inlet to outlet instantly alert operators to precipitator problems because of their recognizable pattern change. Line graphs of recorded data present trend lines that can provide early warning of both precipitator and process problems. The ability to compare the power level of any TR against any other TR in a similar location instantly pinpoints problem areas with the precipitator.

Your particular needs and wants will ultimately determine your choice.

In our next article, we'll give a brief synopsis on how to interpret meter readings.

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Engineering Solutions in the Aftermarket

by Joe DeMartino - Hamon Custodis

Custodis was called to evaluate the stacks at an Ontario Steel Company. It was clear that the stack had to be replaced. This 160 ft. tall 11" ID" stack had seen its better days, and at 20 years of service two, three fuel fire furnaces had spewed more corrosion into this stack than it could any longer bear. In some areas you could see right through to daylight on the other side. (Figure 8)

Fortunately the lower 30 ft., inside the building, was protected from external corrosion and was still in acceptable condition.

Figure 8

Structural Concern

This round stack had a baffle wall separating flue gas from two boilers as seen on Figure 9, but that did not appear to be part of original construction.

Figure 9 - Corroded Dividing Plate

Specification for Retrofit

The typically replacement of an upper portion of a stack is quite routine. However, the customer did not want to simply replace the top 130' of stack. The baffle wall between halves of the stack was intended to act as a barrier should repairs be necessitated on either one of the boiler systems. The severe corrosion, however, precluded this from being effective.

The customer wanted two Independent stacks

This usually means two new stacks with footings, rerouted ducts, new ports etc. But there was no room available in the vicinity of the existing stack for all this work. It was impossible to remove and install two stacks on the same foundation.

Unique Solution

The unique solution was to remove the upper 130 ft. of the stack, and build two "D" shaped stacks on top of the remaining portion. Simple as it sounds this posed a unique problem.

The double "D" stacks must be coupled for bending loads, uncoupled for temperature growth when operated independently, and coupled for some serious shear transfer. Flat walls are much less rigid than normal round stack walls. (Figure 10)

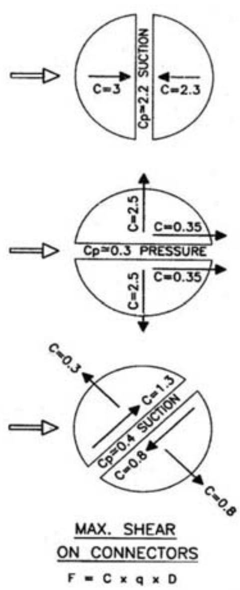

Figure 10

Design Approach

The "Double D" configuration had to take into consideration the forces of compression and tension depending on the wind direction. In conjunction with our fluid dynamics associate we reached an appropriate design using some complex fluid dynamics calculations.

The "Double D" configuration required enhanced stiffening compared to two cylindrical stack of the same surface area. External damping was added to the system by means of foundation damping pads at the base of the new stacks.

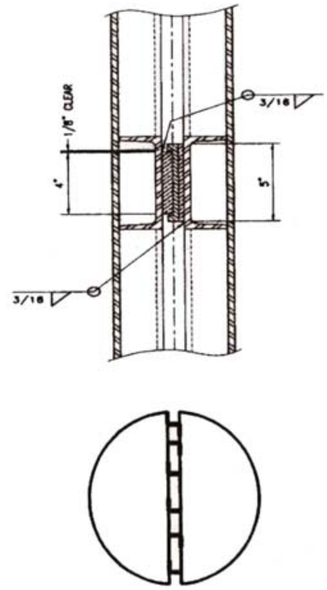

Figure 11

The temperature growth of the hot stack with respect to the cold stack was about 8 inches. Provision for this growth was made by means of slide plate assembly as shown in figure. 11.

Figure 12
Completed Stack

This is typical of many aftermarket projects, where careful consideration at all phases of the project, creative thinking, innovative engineering, and proper construction planning were all key to the successful completion of the project.

WPCA/Duke Scrubber Semniar

June 3, 2004 - Thursday	
8:00 to 8:15	**Welcome by WPCA Chairman** *William Armiger, EPSCO*
8:15 to 8:20	**Saftey Tip,** *Duke Energy*
8:20 to 8:30	**Duke Update** *Jim McCarthy, Duke Energy*
8:30 to 9:30	**Wet Scrubber Systems Fundamentals** *Phil Rader, Alstom*
9:30 to 9:45	**BREAK** *(rooms separated)*
9:45 to 10:30	**Absorber Island Components** *TBA*
10:30 to 11:00	**Oxidation Systems / Equipment**
11:00 to 12:00	**Dewatering Island Components** *TBA*
12:00 to 1:00	**LUNCH** *(provided by Alstom)*
1:00 to 1:30	**Waste Water Handling**
1:30 to 2:00	**Slurry Pumps**
2:00 to 2:15	**BREAK**
2:15 to 2:45	**Agitators**
2:45 to 3:15	**Mixing Vessells**
3:15 to 3:45	**Organic Acids to Boost Scrubber Performance**
3:45 to 4:00	**BREAK** *(rooms combined)*
4:00 to 5:30	**O&M Discussion/ Operational Parameters** *utility and consultant's experience*
5:30 to 6:30	**Alstom Reception**
June 4, 2004 - Friday	
8:00 to 8:15	**Saftey Tip,** *Duke Energy*
8:15 to 9:30	**Planning, Construction and Start Experence** *utility and consultant's experience*
9:30 to 9:45	**BREAK** *(rooms separated)*
9:45 to 10:45	**Limestone Island Components**
10:45 to 11:30	**Scrubber Metallurgy**
11:30 to 12:00	**Piping**
12:00 to 1:00	**LUNCH** *(provided by Alstom)*
1:00 to 1:30	**Booster Fans**
1:30 to 2:15	**Stacks: corrosion, linings, and height** *Custodis*
2:15 to 2:30	**BREAK**
2:30 to 3:15	**CFD for Scrubbers** *Airflow Sciences*
3:15 to 3:45	**Wet ESPs - a finishing device** *Croll-Reynolds*
3:45 to 4:00	**BREAK** *(rooms combined)*
4:00 to 5:30	**O&M Discussion / Maintenance Parameters** *utility and consultant's experience*

For more information contact: sreinhold@reinholdenvironmental.com

WPCA Directors

Hamon Research-Cottrell
Joe De Martino
P.O. Box 1500
Sommerville, NJ 08876 USA
Phone - +1.908.333.2088
Fax - +1.908.333.2152
Email - joe.demartino@hamonusa.com
Website - www.hamon.com

Airflow Sciences Corp.
Robert G. Mudry, P.E.
37501 Schoolcraft Road
Livonia, MI 48150 USA
Phone - +1.734.464.8900
Fax - +1.734.464.5879
Email - wpca@airflowsciences.com
Website - www.airflowsciences.com

Chemithon
5430 West Marginal Way S.W.
Seattle, WA 98106 USA
Phone – +1.206.937.9954
Fax - +1.206.932.3786
Website – www.chemithon.com

EPSCO International
William Armiger
113 Edward Wyatt Drive
Williamsburg, VA 23188 USA
Phone - +1.757.258.3453
Fax - +1.757.258.4535
Email – info@epsco.biz
Website- www.epsco.biz

CoorsTek
John Cook
1600 Table Mountain Pkwy.
Golden, CO 80403 USA
Phone - +1.303.278.4000
Fax - +1.303.278.
Email - jcook@coorstek.com
Website - www.coorstek.com

Croll-Reynolds
Buzz Reynolds
P.O. Box 668
751 Central Ave.
Westfield, NJ 07090 USA
Phone - +1.908.232.4200
Fax - +1.908.232.2146
Email - breynolds@croll.com
Website - www.croll.com

BHA Group
Mike Sedler
8800 East 63rd. Street
Kansas City, MO 64133
Phone - +1.800.821.2222
Fax - +1.816.353.1873
Email - msedler@bha.com
Website - www.bha.com

REDKOH Megamation
Paul Ford
Units 1-4, Building 29
125 Stryker Lane
Hillsborough, NJ 08844 USA
Phone - +1.908.874.5588
Fax - +1.908.874.7994
Email – paulford@redkoh.com
Website – www.redkoh.com

Reinhold Enviromental
Susan Reinhold
853 Sanders Road
Suite 308
Northbrook, IL 60062 USA
Phone - +1.847.291.7396
Fax - +1.847.498.1512
Email - sreinhold@reinholdenvironmental.com
Website -www.reinholdenvironmental.com

Haldor Topsoe
Nathan White
17629 El Camino Real
Suite 300
Houston, TX 77058-3051 USA
Phone - +1.281.228.5127
Fax - +1.281.228.5129
Email -tnw@topsoe.com
Website -www.haldortopsoe.com

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WPCA News Information Request

Tamra Hartley
Managing Editor
Reinhold Environmental

1284 Hwy. 17
Montevallo, AL 35115
USA

Phone/Fax-
+1.205.665.9842
Email- thartley@
reinholdenvironmental.com