POWER Engineering
January 2001 the magazine of power generation technology

Wet Electrostatic Precipitation Demonstrating Promise for Fine Particulate Control

By
Ralph Altman EPRI
Wayne Buckley and Dr. Isaac Ray, Croll-Reynolds Clean Air Technologies

CROLL-REYNOLDS
CLEAN AIR TECHNOLOGIES
P.O. Box 668, 751 Central Avenue • Westfield, NJ 07091-0668
Tel: (908) 232-4200 • Fax: (908) 232-2146 • Web site: www.croll.com • E-mail: info@croll.com
Engineering Air Pollution Control Systems

Wet Electrostatic Precipitation Demonstrating Promise for Fine Particulate Control

Part I

Editor's Note: Part l of this two-part feature on wet electrostatic precipitation (wet ESPs) outlines the need for multi-pollutant air pollution control technologies, the basics of wet and dry electrostatic precipitation, the ability of wet and dry ESPs to treat fine particulate, and the use of wet ESP technology at Northern States Power Company's Sherco Station. Part II will explore the key design considerations associated with wet ESP technology, compare plate and tube-type configurations, and examine the use of wet ESPs at Potomac Electric Power Company's Dickerson Station.

Power plants are coming under increased scrutiny from regulators, the public and environmental groups. The ready availability of information about power plant emissions, along with a growing belief among regulators that acid gases, fine particulate and toxic chemicals adversely affect the environment and human respiratory systems, are expected to force power plants to control their emissions to a much greater degree than ever before. The U.S. Environmental Protection Agency (EPA) has proposed regulating $N0_X$, $S0_X$, PM2.5 and possibly mercury in addition to existing regulations for PM10 and $S0_2$. The trend is apparent: EPA is seeking to control a multitude of pollutants that are comprised of smaller and harder-to-capture sub-micron particles, mists and metals.

Industrial facilities have dealt with multi-pollutant regulations for many years, and have demonstrated successful control. For almost a century, in fact, wet electrosatic precipitators (wet ESPs) have been standard technology in sulfuric acid plants to abate $S0_3$ mist, a sub-micron particle. However, wet electrostatic precipitation is a relatively unknown technology to most industries and power producers because air regulations up to recently have not required the extremely high levels of control of sub-micron particulate that can be achieved by wet ESPs. Though a typical industrial power boiler's air volume is only 50,000-150,000 cfm, and a typical power boiler has an air flow of approximately 500,000-1,500,000 cfm, the chemistry of the pollutants and size of the particles being emitted are, in many applications, similar to those of a fossil-fueled generating unit.

Most industrial and nearly all power facilities already have some sort of dry technology installed to control particulate emissions, such as a cyclone, fabric filter or dry ESP. Where acid gases or moist particulate may be present in a gas stream, a scrubber or gas absorber is typically in place. However, as regulations emerge requiring more stringent control of sub-micron particulate—which includes acid mists and low and semi-volatile metals as well as soluble gases such as certain mercury compounds and dioxins/furans—wet ESP technology is increasingly attractive as a final emissions polishing device due to its low pressure drop and high removal performance.

ESP BACKGROUND

Electrostatic precipitation consists of three steps: (1) charging the particles to be collected via a high-voltage electric discharge, (2) collecting the particles on the surface of an oppositely charged collection electrode surface, and (3) cleaning the surface of the collecting electrode. Table 1 compares velocities for different particle sizes under various forces. As particles become smaller, gravitational and centrifugal forces become less powerful, while electrical and, to a lesser degree, Brownian forces become greater, especially for 0.1 to 0.5-micron particles. It is evident that electrical collection is an effective method for separating sub-micron particles from the gas stream.

Table 1
Particle Displacements in Standard Air Due to Various Force Fields

Particle Diameter (microns)	Displacement in 1 second				
	Cc*	Grav.**	Cent***	Elect.****	Brown*****
10.0	1.016	0.024	20.5	0.98	0.0000057
1.0	1.165	0.00027	0.235	0.11	0.0000194
0.1	2.93	0.0000069	0.0059	0.27	0.0000972
0.01	22.6	0.00000053	0.00046	2.12	0.0008540

* Stokes Cunningham slip-correction factor (dimensionless)

** Gravitational force field: downward linear displacements based on 32.2 ft/s^2 acceleration

*** Centrifugal force field: outward radial displacements based on 862 g's acceleration

**** Electrostatic force field: normal linear displacements based on 7500 V/inch field strength and a saturation charge on the particles

***** Brownian movement: random linear displacements based on average values

Most importantly, whereas mechanical collectors exert their force upon the entire gas, ESPs exert their force only upon the particles to be collected. ESPs typically operate at approximately 0.5-1.0 inch pressure drop, regardless of air volume or particle size. Alternatively, a mechanical collector such as a venturi scrubber would have to operate at approximately 60 inches of water column to achieve 95 percent collection efficiency on 0.5-micron particles. This is a major reason why dry ESPs are predominantly used in the power industry. Every inch of pressure drop translates into dramatically higher energy requirements for operating the ID fan. To achieve 95 percent removal efficiency on 0.5-micron particles in a 1,000,000 cfm air flow, 12,000 kW of energy is required using a scrubber, while an ESP needs only 100-200 kW of energy.

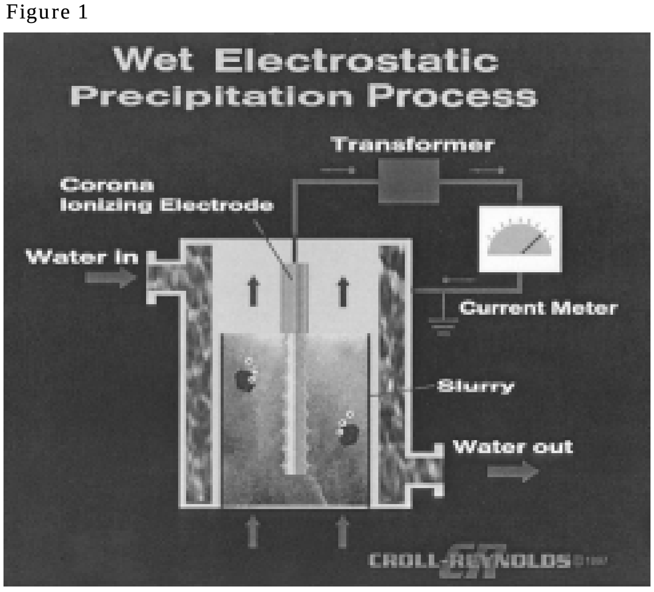
DRY ESPs

Dry ESPs consist of a series of parallel vertical plates, which act as the collecting electrodes, with a series of discharge electrodes in between the plates spaced some distance apart. As the contaminated flue gas passes through the ESP, negatively charged ions form near the tips of the sharp points of the ionizing electrode (corona discharge). These negatively charged ions move toward the grounded collecting electrode surface and charge the contaminated particles passing through the ESP. These charged particles become attracted to the positively charged collection plate, where they accumulate on the surface. The collected particulate builds up on the dry collection surface and forms a layer of particles or "cake" that has insulating properties.

Dry ESPs typically have a minimum collection efficiency when encountering particles in the 0.5 to 1.0 micron range. Smoke plume from a stack is the clearest sign of the presence of sub-micron particles in a gas stream. Due to refraction of sunlight, 0.5 micron particles are the most visible. Additionally, the surface area of the smallest particles in a flue gas is greater than the surface area of larger particles. One gram of 0.1 micron particles has 10 times the surface area as a gram of 1.0 micron particles (60 m_2 vs 6.0 m_2). Toxic vapors however, condense uniformly on the surface area of all particles. That is why the capture of a gram of 0.1-micron ash particles is 10 times more effective at removing toxic pollutants than the capture of a gram of 1.0-micron ash particles.

Dry ESPs perform best when particle deposits on the collecting plates have a resistivity greater than approximately 10^7 ohm-cm, but less than 2×10^{10} ohm-cm. If resistivity is less than 10^7, the electrostatic force holding the dust particles on to the dust layer is too low and re-entrainment of particles in the flue gas may become a serious problem, reducing collection efficiency. If resistivity exceeds 2×10^{10} ohm-cm, the voltage drop through the particle layer to the grounded electrode becomes significant, lowering field strength in the space between the ionizing electrode and the top of the dust layer. This may cause a breakdown in the electrical field and sparking or "back corona" can take place, again lowering efficiency. Resistivity becomes a limiting factor to the amount of electrical power that can be achieved within a dry ESP.

Figure 1



To dislodge the dustcake from the collecting electrode surface and into the bottom hopper, mechanical rappers or sometimes sonic horns are employed. However, portions of the particles remain suspended in air and get re-entrained in the gas stream. This secondary re-entrainment requires the use of multiple dry ESP fields to collect the re-entrained particulate plus those particles not captured in the first field.

Dry ESPs have been used successfully for many years in industrial and power plant applications for coarse and fine particulate removal. Dry ESPs can achieve 99+ percent efficiency for particles 1 micron to 10 micron in size. However, they have several limitations that prevent their use in all applications:

- *Due to their low corona power levels because of high resistivity of the particulate dust layer, dry ESPs cannot efficiently collect the very small fly ash particles less than 0.5 microns in diameter.*
- *Dry ESPs cannot handle moist or sticky particulate that would stick to the collection surface.*
- *Dry ESPs require a lot of real estate for multiple fields due to re-entrainment of particulate.*
- *Dry ESPs rely on mechanical methods to clean the plates, which require maintenance and periodic shutdowns.*

Therefore, dry ESPs may not be the most practical control device to meet the proposed PM2.5 standard, or to collect acid mist.

WET ESPs

Wet ESPs operate in the same three-step process as dry ESPs— charging, collecting and finally cleaning of the particles. However, cleaning of the collecting electrode is performed by washing the collection surface with liquid, rather than mechanically rapping the collection plates (Figure 1). While the cleaning mechanism would not be thought to have any impact upon performance, it significantly affects the nature of the particles that can be captured, the performance efficiencies that can be achieved, and the design parameters and operating maintenance of the equipment. Simply stated, wet ESP technology is significantly different than dry ESP technology.

Because wet ESPs operate in a wet environment in order to wash the collection surface, they can handle a wider variety of pollutants and gas conditions than dry ESPs.

Wet ESPs find their greatest use in applications where gas streams fall into one or more of the following categories:

- *The gas in question has a high moisture content;*
- *The gas stream includes sticky particulate;*
- *The collection of submicron particulate is required;*
- *The gas stream has acid droplets or mist-SO_3,*
- *The temperature of the gas stream approaches the gas dew point.*

Because wet ESPs continually wet the collection surface area and create a dilute slurry that flows down the collecting wall to a recycle tank, the collecting walls never build up a layer of particulate cake. Consequently, the captured particulate is not re-entrained.

In addition, when firing low sulfur coal, which produces a high resistivity dust, there is no deterioration of the electrical field due to high resistivity, and power levels within a wet ESP can be dramatically higher than in a dry ESP. Typical operating power within a wet ESP may be as high as 2,000 watts per 1,000 cfm, while that of a dry ESP is limited to 100-500 watts per 1,000 cfm. The ability to inject much greater electrical power within the wet ESP is the main reason a wet ESP can collect submicron particulate so efficiently.

Northern States Power Company's Sherco Station. Photo courtesy of Northern States Power.

POWER PLANT DEMO

While the versatility of wet ESPs has been demonstrated in diverse industrial applications, the added complexity relative to conventional dry ESPs has discouraged its use by the power industry until recently. However, the growing pressure to limit particulate and other emissions is providing new motivation to examine the applicability of this technology to coal-burning power plants. Early studies indicate that the unique characteristics of a power boiler application must be successfully addressed before this transition will occur.

In particular, a wet ESP design must be compact, economical and reliable to compete in the power arena. Furthermore, it should have minimal impact on upstream and downstream plant equipment. Two totally different designs seem to satisfy these requirements. The first design, an upflow tubular design, has been installed in the outlet of the scrubber modules at Northern States Power Company's Sherco Station. The second design, a horizontal flow plate design, was recently installed at Potomac Electric Power Company's Dickerson Generating Station (At the time of the writing of this article, Dickerson was under contract to be purchased by Southern Energy Inc.). Both designs have unique features that make them particularly attractive for these specific applications and illustate how this technology can be adapted for electric generation application.

While the key design considerations associated with wet ESP technology will be explored in greater detail in Part II of this feature, a review of the Sherco application provides a glimpse into the challenges and opportunities possible with wet ESPs.

Northern States Power Company's Sherco Station provided a unique opportunity to use a wet ESP to solve a difficult particulate emissions problem. Units 1 and 2 at Sherco are equipped with venturi scrubbers that were designed to control both SO_2 and particulate emissions. Each 750 MW unit has twelve 75 MW scrubbers (two spares) that utilize an adjustable rod deck venturi for particulate capture. However, the venturis were not very successful in capturing the very fine particles produced by the Powder River Basin coal burned at Sherco.

An engineering study of upgrade options led to the conclusion that modification of the outlet section of the scrubber to replace the mist eliminator with a two-field up-flow wet ESP should solve the particulate emission problem at a cost far less than the most attractive alternate solution, the addition of a baghouse upstream of the scrubbers. The ESP addition made it necessary to move the scrubber sprays from the up-flow section of the scrubbers to the horizontal crossover section connecting the down-flow and up-flow scrubber sections. This requirement raised questions about the impact of conversion on $S0_2$ emissions and, of course, there was no previous experience on which to base particulate capture performance.

These uncertainties resulted in EPRI's participation in the project. EPRI contributed to the modification of the first 75 MW module and to a test program to quantify the impact on both $S0_2$ and particulate emissions. In fact, the modification proved to be very successful. The test program determined that an $S0_2$ removal of 70 percent or greater could be maintained by the scrubber, the outlet particulate emissions were in the 0.01 lb/MMBtu range, and the opacity in the duct following the modified scrubber modules could be maintained below 10 percent. Since the modification met or exceeded all of the emission requirements, the decision was made to follow through with the conversion of all of the modules to wet ESP operation. By the end of December 2000, 18 out of the 24 scrubber modules had been converted to wet ESP operation. The performance of all of the converted modules is comparable to that of the original test module, with SO_2 removal levels in the 70% percent range and particulate emissions, as indicated by opacity, in an acceptable range. Conversion of all of the modules will be completed by end of summer 2001.

Wet Electrostatic Precipitation Demonstrating Promise for Fine Particulate Control

Part II

Editor's Note: Part II of this two-part feature on wet electrostatic precipitation (wet ESPs) explores the key design considerations associated with wet ESP technology, compares plate and tube-type configurations, and examines the use of wet ESPs at Southern Energy's Dickerson Station.

As discussed in Part I of this feature (Power Engineering, January 2001), wet ESPs are particularly effective for fine particulate control. They differ considerably, however, from their dry ESP counterparts. In wet ESPs, the delivery mechanism for the irrigating liquid is either via a series of spray nozzles or via condensing moisture from the flue gas on the collection surface. Proper design of the spray system and water treatment system is required for high-power operation and low maintenance requirements. Some type of weir may be employed, but maintaining a thin film of liquid on the collection plate is problematic. Additionally, the use of recycled spray water requires water treatment to maintain acceptable corrosion levels within the ESP.

A second means of irrigating the collection plates is through flue gas water condensation. In a condensing wet ESP, moisture in the gas creates a thin film of water over the entire surface of the collecting electrode. Cooling the collection surface below the temperature of the flue gas forms the condensate. The temperature differential between the cold wall of the collecting tube and the hot saturated gas condenses moisture present in the gas. The condensation forms a uniform, evenly distributed liquid film on the collection surface, which continuously washes the collection surface. The condensed moisture is collected in a recycle tank where it is treated and typically sprayed back into the process in the pre-scrubbing section of the wet ESP. The liquid used to cool the collecting surfaces never comes into contact with the process and is continuously recirculated. This method reduces the demand for fresh water by creating fresh water from the condensation of moisture in the gas stream, and also minimizes treatment of the recycle liquid. Typically, only a small bleed stream is required and the treated wastewater is recycled back into the wet ESP for re-use, minimizing fresh water make-up.

TUBULAR VS. PLATE

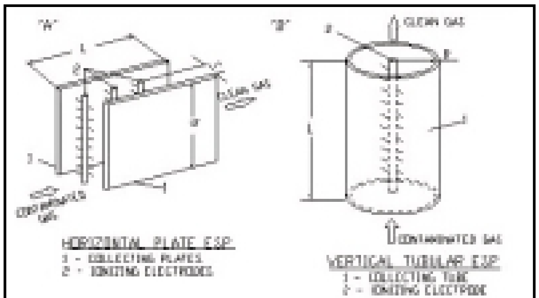
Wet ESPs can be configured either as tubular precipitators with vertical gas flow or as plate precipitators with horizontal gas flow (Figure 1). For a utility application, tubular wet ESPs would be appropriate as a mist eliminator above a FGD scrubber, while the plate type could be employed at the back end of a dry ESP train for final polishing of the gas. In general, tubular precipitators are more efficient than the plate type and take up less space due to simple geometry. A tubular wet ESP is just a horizontal ESP turned vertical with all four sides enclosed to act as collection surface. Other differences between the two types are:

- *For a given efficiency, a tubular precipitator may be operated at twice the gas velocity of a plate precipitator of equal electrode length.*
- *For a given efficiency, a tubular precipitator has a smaller footprint than a plate type precipitator.*

Tubular precipitators can be designed as either up-flow or down-flow. In up-flow tubular ESPs, flue gas enters at the bottom of the ESP and flows upwards. The wash nozzles are located at the bottom spraying up into the ESP, co-current with the gas. In some cases, nozzles that spray down into the field are added above the field. In down-flow designs, the flue gas enters the top of the wet ESP and flows downwards. Similarly, the sprays are mounted on top, spraying down co-current with the gas.

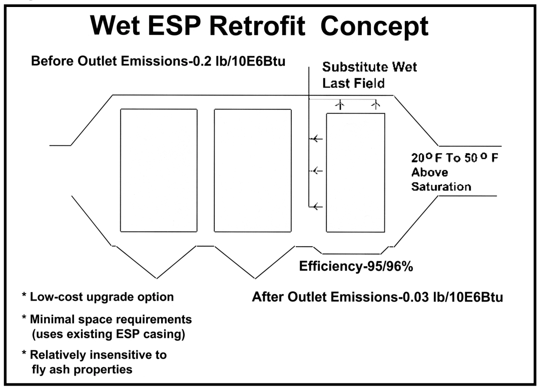
While in some installations a down-flow design may minimize inter-connecting ductwork, it may require a mechanical mist eliminator to capture the water mist that has been carried along with the flue gas before entering the stack. Conversely, an up-flow, tubular wet ESP is an excellent mist eliminator due to its ability to capture sub-micron droplets and requires no mechanical mist eliminator. However, water droplets from the bottom spray (40 microns in size or more) never reach the upper portion of the tube where most of the sub-micron particulate accumulates. Therefore, frequent ESP shutdowns are required to wash the unit down using top wash nozzles. In an up-flow design, using the condensing type of wet ESP design overcomes this handicap.

Figure 1



The comparison of a tubular WESP vs. a plate type WESP shows that for a given efficiency, a tubular WESP can operate at twice the velocity of a plate type WESP, resulting in a smaller footprint (Applicable mostly for new configuration).

Figure 2



AIR DISTRIBUTION

Distribution of the flue gas throughout the wet ESP is a critical design function. Overloading a section of the wet ESP will negatively impact collection efficiency. While perforated plates below the electrical section will aid in proper air flow distribution, an alternative is using some sort of scrubber in front of the wet ESP. This accomplishes multiple purposes:

- *Removal of any acid gas present, which reduces corrosion in the wet ESP and allows for less expensive materials of construction to be used (ie., FGD application)*
- *Removal of particulate larger than 2 microns, which reduces the particulate loading on the wet ESP and allows for smaller size of the wet ESP*
- *Cooling of the gas, which reduces the gas volume and cuts down on the size of the wet ESP*
- *Saturation of the gas, which enhances condensation within the wet ESP*
- *Enhanced air flow distribution throughout the wet ESP, which enables maximum removal efficiency.*

SPARKING

Since wet ESP efficiency is directly proportional to the electrical power conveyed to the moving gas, each time a spark occurs, the voltage, and consequently the particulate collection efficiency, is reduced. Sparking rate for a given inter-electrode spacing is a function of the inlet loading (mist, droplet or particulate) and alignment of the discharge electrodes. Additionally, the power level and efficiency of a wet ESP can be dramatically increased by properly designing the automatic voltage control system. While the industry average seldom goes beyond 50 percent conduction (i.e., the ability to deliver 50 percent of the available power to the gas), the proper selection of the transformer-rectifier (T/R) and automatic voltage controller (AVC) can deliver much greater conduction.

CORONA CURRENT SUPPRESSION

If there is a high loading of charged particles, the corona current is diminished due to the low mobility of charged particles in the inter-electrode space. This phenomenon is called current suppression or space charge effect. A high concentration of fine particles, a typical scenario for space charge effect, can reduce the corona current by a factor of 50 or more.

Certain criteria should be met in order to prevent the deterioration of removal efficiency in the presence of a space charge effect. The level of current suppression that will be experienced in a particular application is related to the total surface area of the suspended particles and the designed corona current density within the given volume of the wet ESP collection section. For example, particles of 1.0-micron diameter have 6.0 m^2/gram of surface, whereas particles of 0.1-micron diameter have more than 10 times the surface area per unit weight (60.0 m^2/gram). For a given grain loading, the finer the particle, the more potential there is for current suppression to occur.

There are several design options that can reduce current suppression:

- *If possible, reduce the inlet loading to the wet ESP, through the use of a more efficient precleaner, to a level below which current suppression will likely not occur.*

- *Provide a method of sub-cooling the flue gas, below adiabatic saturation, in order to take advantage of the effects of flux force condensation on particle growth and agglomeration.*
- *Design the discharge electrode and the inter-electrode spacing to provide the lowest possible corona starting voltage and the highest possible corona current density.*
- *Select the optimum residence time (i.e. gas velocity) in the wet ESP to ensure the maximum possible particle charging under suppression conditions*
- *Sectionalize the wet ESP into multiple sections or fields with independent power supplies for each section.*

In the case of multiple fields in a wet ESP, collection efficiency can be maintained even in the presence of current suppression. The first pass will operate in "suppressed" conditions at a somewhat reduced efficiency level, but will condition the gas for the second pass, which will operate at its full design potential.

MATERIALS OF CONSTRUCTION

A wet ESPs collection section can be made out of any conductive material. However, the material chosen must be corrosion resistant to any acid mist contained in the flue gas. Wet ESPs have been made out of conductive fiberglass, carbon steel, various stainless steels and various high-end alloys depending upon the duty intended. Most industrial multi-pollutant applications for wet ESPs typically employ some sort of scrubber in front of the wet ESP to remove corrosive acid gases. Material selection should be based upon a "worst-case" scenario analysis in order to protect the equipment against upset conditions. Alternatively, the water sprayed into the ESP can be treated to neutralize acids collected within the ESP.

MODULAR

Like dry ESPs, wet ESPs can be modular. Each field is limited in size to the power of the transformer. The largest transformers available today are 70,000 V @ 2500 mA of installed electrical power. Depending on the specific application (large air flow or heavy inlet loading), multiple sections can be arranged together, either in series or in parallel, to achieve the required efficiencies. Where a dry ESP train already exists, the last field can be retrofitted into a wet field for final polishing of the flue gas.

COLLECTION EFFICIENCY

For a given particulate or droplet size and concentration, ESP efficiency can be calculated by using the exponential Deutsch-Anderson equation. Field experience has shown that, with some modification, the same equation can also be applied to wet ESPs. The Deutsch-Anderson equation is:

$$Eff = 1 - Exp(-Aw/V)$$

where the collecting electrode surface area, A, and volumetric flow rate, V, are calculated from the known geometry of the ESP and the process design data. The drift, or migration velocity, w, is determined by the operating power and particle size distribution.

There are two types of charging processes at work in an ESP. For particles greater than 1 micron, "field-charging" is primary and refers to particles being charged through the collision of negative ions as they follow the electric field lines to the surface of the particles. The peak operating voltage is the most important factor in field-charging. For particles smaller than 0.5 micron, "diffusion-charging" is primary and occurs because of the random motion of the sub-micron particles and their collision with negative ions. The current density injected into the ESP is the most important factor in diffusion-charging.

Dickerson Station. Photo courtesy of Southern Energy.

Wet ESPs are capable of removing sub-micron droplets, acid mists, metals and mercury particles as small as 0.01 micron in size with up to 99.9% removal efficiency. Near zero opacity can be achieved. When integrated with upstream control equipment, such as scrubber, multiple pollutants can be removed. At a major hazardous waste facility with over 2,000 waste streams, an APC system featuring a quench, a scrubber followed by a two stage tubular, wet ESP achieved 99.9% removal of all pollutants-acid gases, dioxins/furans, PM2.5, metals and near 80% for mercury.

Parameter	Units	Average	Removal %	MACT Limit
Particulate	mg/dscm, 7% O_2	5.5 - 6.9	99.95%	34
	(gr/dscf, 7% O_2)	(0.0024 - 0.0030)		(0.015)
HCl / Cl_2	ppmdv, 7% O_2	3.0 - 4.8	99.95%	77
Chromium	µg/dscm, 7% O_2	40 - 43	99.97%	97
Lead	µg/dscm, 7% O_2	3.6 - 3.9	99.95%	240
Mercury	µg/dscm, 7% O_2	1.9 - 5.0*	78%	130
Dioxins/Furans	ng TEQ/dscm, 7% O_2	<0.013 - <0.089[5]	99.9%	0.4

At a mining operation where SO3 mist (H2SO4) and PM2.5 contributed to high opacity levels, a combined scrubber/wet ESP system achieved 99%+ on SO2 removal and zero opacity from the stack. A plume once seen from forty miles away and a visible eyesore to the local environment was eliminated.

Similar results are found in the pulp & paper, wood products, textile, carpet, chemical and many other industries where wet ESPs have been installed and properly designed. Typically, wastewater is treated in a plant's wastewater facility or where none exists, a skid mounted packaged wastewater treatment system is supplied. In some cases, precious oils and chemicals can be recovered and reused elsewhere in a plant

UTILITY DEMO

As noted in Part I, growing pressures on utility plants to reduce emission levels are providing new motivation to examine the applicability of wet ESP technology to coal-burning power plants. While the experience at Sherco Station (Part I) indicates that wet ESPs can be used in scrubber applications, there is a project currently underway to see if this technology could have even broader application to the utility industry. This work is being done at Southern Energy's (formerly Pepco's) Dickerson Station. At this plant, the ESP on the 182 MW (net summer) Unit 3 is being converted to hybrid operation. The first two fields of the ESP remain unchanged. However, the internals of the last field of the three-field ESP are being removed and replaced with a wet field (Figure 2). The ESP casing surrounding the third field will be wallpapered with a moderate-grade stainless steel, and the new internals will also be made of a stainless steel alloy.

The goal of this conversion is to meet the plant's very strict opacity limits (10 percent or less). Since the existing ESP has a specific collection area of only 120 ft^2/l,000 acfm, achieving this goal will not be easy. However, an extensive ESP performance optimization program conducted by Dickerson plant personnel has demonstrated the dry ESP alone is capable of operating at a level close to meeting the required opacity limit. ESP performance modeling also indicates that the conversion of the last field to wet operation should control emissions to below the limit.

The modeling was based on results from two large-scale wet ESP pilot tests conducted by EPRI. These results indicate that a single wet field can achieve very high collection efficiency, greater than 90 percent. In terms of outlet emissions, the tests indicated that an ESP emitting more than 0.1 lb/MMBtu before conversion would emit less than 0.03 lb/MMBtu after conversion. This high efficiency results from the high power levels possible when fly ash electrical resistivity is no longer a controlling factor. Furthermore, the water wash system in the wet field eliminates the need for traditional mechanical rapping and thus virtually eliminates all re-entrainment losses. The EPRI tests also established that a wet ESP can be successfully operated with the flue gas temperature well above the moisture dew point. This method of operation means that equipment downstream of the converted ESP will not have to be operated in a wet environment. Finally, the EPRI tests demonstrated that the conversion to wet operation reduced SO_2 and other acid gas emissions slightly, indicating that this technology may evolve into a multi-pollutant control technology.

The unit is being converted as this article was written. Preliminary performance results will be available in early 2001. These results will quantify performance and examine corrosion and other water chemistry issues. It will also be determined if continuous operation above the moisture dew point can also be achieved.

Authors—

Ralph Altman is a Project Manager at EPRI. For the past 22 years, he has managed EPRI's research on electrostatic precipitators and participated in the management of research on other particulate control technologies. Altman holds a B.S. degree in mechanical enginering and M.S. and Ph.D. degrees in physics from the Georgia Institute of Technology, and an MBA from the University of Tennessee at Chattanooga.

Wayne Buckley is Vice President, General Manager of Croll-Reynolds Clean Air Technologies. He has more than 30 years' experience in the refractory, incineration and air pollution control industries. Buckley received a bachelor's degree in mechanical engineering from New York University.

Dr Isaac Ray is Vice President, Research & Development with Croll-Reynolds Clean Air Technologies. He has worked extensively in the air pollution control industry, specializing in wet ESP technology. Dr. Ray received a Ph.D. in mechanical engineering from the Civil Engineering Institute, Odessa, USSR.

CROLL-REYNOLDS

CLEAN AIR TECHNOLOGIES

P.O. Box 668, 751 Central Avenue • Westfield, NJ 07091-0668

Tel: (908) 232-4200 • Fax: (908) 232-2146 • Web site: www.croll.com • E-mail: info@croll.com