BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

NOTICE

TO: Dorothy Gunn
Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

SEE ATTACHED SERVICE LIST

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Illinois Pollution Control Board the AMENDED TESTIMONY OF JAMES E. STAUDT, Ph.D., a copy of which is herewith served upon you.

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: ______________________
Gina Roccaforte
Assistant Counsel
Division of Legal Counsel

DATED: May 19, 2006

1021 North Grand Avenue East
P. O. Box 19276
Springfield, IL 62794-9276
217/782-5544

THIS FILING IS SUBMITTED ON RECYCLED PAPER

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF:	)	
	)	R06-25
PROPOSED NEW 35 ILL. ADM. CODE 225	)	(Rulemaking – Air)
CONTROL OF EMISSIONS FROM	)	
LARGE COMBUSTION SOURCES(MERCURY)	)	

AMENDED TESTIMONY OF JAMES E. STAUDT, Ph.D.

I, James E. Staudt, have been retained by the Illinois Environmental Protection Agency (IL EPA) as an expert in this electric power plant mercury emissions rule development.

I expect to testify at the hearing on the current state-of-the-art of mercury emissions control technology for coal-fired power plants and the potential use of these control technologies by Illinois coal-fired power plants to comply with the rule that has been proposed by IL EPA.

I. BACKGROUND AND QUALIFICATIONS

I am currently the President of Andover Technology Partners ("ATP"). As President of ATP, I have advised power plants, equipment suppliers and government agencies on ways to comply with emissions regulations in cost-effective ways. For nearly twenty years, I have worked in the field of air pollution control technology, including mercury emissions control. For the past nine years (since 1997) I have been a consultant with my own business – Andover Technology Partners. My primary area of business as a consultant is associated with my expertise relating to the performance and cost of air pollution control technologies on power plants. Clients have included the US EPA, power plant owners, technology suppliers, and others. I have published several papers and reports, including papers in peer-reviewed journals and reports issued by the US EPA, on mercury control technology and the cost of controlling mercury on power plants. Several of these papers have been coauthored with staff of the US EPA. For most of the period from 1988 to 1997 I was employed by companies that supplied air pollution control technology (Research Cottrell and Fuel Tech) or power plant and refinery gas analyzers (Spectrum Diagnostix, a subsidiary of Physical Sciences that was acquired by Western Research). As an employee of these companies over this period I sold, designed, and commissioned air pollution control technology at numerous power plants and industrial facilities.

I received my M.S. (1986) and Ph.D. (1987) in Mechanical Engineering from the Massachusetts Institute of Technology. I received my B.S. in Mechanical Engineering from the U.S. Naval Academy in 1979. From 1979 to 1984 I served as a commissioned officer in the U.S. Navy in the Engineering Department of a nuclear-powered aircraft carrier.

II. SUMMARY OF TESTIMONY

At the Hearing I expect to testify on how mercury emissions from coal power plants can be controlled and what those controls are expected to cost Illinois power plants that will be required to comply with the proposed mercury control rule should it be finalized. By reference, my testimony includes Section 8 of the Technical Support Document (TSD): Technological Feasibility of Controlling Mercury Emissions from Coal-fired Power Plants in Illinois.

Mercury Emissions From Coal Fired Power Plants

The mercury emissions from a coal-fired power plant are the result of the mercury content in the coal that is burned and the extent that processes in the boiler prevent the mercury from being released with the exhaust gases of the power plant. Mercury may be removed from the coal prior to combustion of the coal. This may be achieved by coal cleaning or by some other treatment of the coal. Or, mercury may be removed from the boiler flue gases by Air Pollution Control (APC) equipment. Sometimes the APC equipment that removes the mercury is equipment that is installed primarily to remove other pollutants, such as Particle Matter (PM) or acid gases in a Flue Gas Desulfurization system (FGD, also called SO_2 scrubbers). Mercury removal in this manner is called co-benefit mercury removal. Mercury may also be removed by air pollution control systems that are specifically designed to remove mercury from the flue gases.

Mercury Removal from Coal

Run of mine (ROM) bituminous coal is frequently cleaned for the following purposes:

- Removal of impurities to improve the heating value of the coal
- Reduction of transportation costs for coal to the power plant and ash from the power plant
- Maintenance of ash content in coal supply within contract requirements
- Removal of sulfur, mainly as pyrites, lowering SO_2 emissions when the coal is burned.

However, cleaning ROM coal will provide the added benefit of removing mercury from the coal. This is because mercury in the coal is preferentially associated with pyrites and other non-combustible materials that are removed in coal washing. Mercury removal from the coal before combustion through washing will contribute to lower mercury emissions from the plant.

Mercury Behavior In the Furnace and Cobenefit Capture

Mercury that is present in trace amounts in the coal is released from the coal during combustion. At furnace conditions, the released mercury is present in a gaseous state in the elemental form that is denoted as Hg^o. As the combustion exhaust gases cool in the boiler, chemistry shifts to favor an oxidized, or ionic, form of mercury, denoted as Hg^{2+}. Some of the Hg^{2+} is adsorbed onto particles to form $Hg_{p.}$ The Hg_p is readily captured in PM emission control devices that all IL coal power plants are equipped with – ESPs or fabric filters. Hg^{2+} is water soluble and can be captured by FGD systems if they are installed. However, not all of the Hg^o becomes Hg^{2+} or Hg_p due to limitations on the chemistry that result from several factors, such as concentration of chlorine (the most common form of Hg^{2+} is $HgCl_2$), flue gas temperature, and other factors. As a result of this, the level of cobenefit mercury capture in the PM emission control devices or SO_2 scrubbers may vary based upon the type of equipment, the constituents in the coal, and other factors. NOx controls, such as Selective Catalytic Reduction (SCR) and combustion staging, can enhance the capture that is achieved in PM or SO_2 controls. Results of measurements of co-benefit mercury removal rates taken in response to the U.S. EPA's Information Collection Request (ICR) as part of the development of the federal Clean Air Mercury Rule and subsequent test programs since the ICR program provided data that indicates that the following cobenefit removal rates may be expected:

- For pulverized-coal boilers firing bituminous coal and equipped with SCR, and ESP, and wet FGD, co-benefit mercury capture is expected to be about 90%.
- For pulverized-coal boilers firing bituminous coal and equipped with an ESP, co-benefit mercury capture is expected to be in the range of about 30%-50%.
- For boilers firing bituminous coal in a circulating fluidized bed (CFB) arrangement with a fabric filter, co-benefit mercury capture over 90% is expected to be achieved.
- For pulverized-coal boilers firing subbituminous coal and equipped with only an ESP, low co-benefit mercury capture is expected.
- For pulverized-coal boilers firing any kind of coal and equipped with only a hot-side ESP, co-benefit mercury capture is expected to be low.

Cobenefit controls may be optimized through a variety of techniques that are described in more detail in the TSD. Depending upon the fuel being fired and the boiler's configuration, optimization methods can significantly improve cobenefit mercury removal.

Mercury-Specific Controls, Especially Sorbent Injection

The previous section addressed the important factors impacting mercury capture by co-benefit from NOx, PM or SO_2 control technologies. As discussed, boilers that fire subbituminous coal – which there currently are many of in Illinois – are not likely to achieve high levels of mercury removal from co-benefits alone. Some of the bituminous coal fired boilers may not achieve adequately low mercury emissions by co-benefits alone. Therefore, these plants may need additional controls to achieve the levels of mercury removal that are being required in the proposed rule.

Although many mercury control methods are under development, sorbent injection is clearly the most developed. It is the only approach that has been tested on several coal-fired boilers firing a wide range of fuels. Power companies have entered contracts for commercial systems, some with statutory requirements to achieve 90% or more mercury removal. Moreover, injection of sorbent, particularly Powdered Activated Carbon (PAC), has been used for mercury control on hundreds of municipal waste combustors in the United States and in Europe for several years. The equipment is fairly simple, relatively easy to install, relatively inexpensive in capital cost, and it is well understood. The sorbent, PAC, is widely available from several suppliers.

There are three ways that the sorbent can be admitted to the gas stream:

- Normal sorbent injection – upstream of the existing ESP or fabric filter and the most inexpensive approach. Typical capital cost is around $2/KW
- TOXECON – An acronym for TOXic Emission CONtrol device. This entails retrofitting a fabric filter downstream of the existing ESP and injecting the sorbent into the gas stream between the ESP and the fabric filter with the fabric filter capturing the sorbent. This approach has been shown to work very effectively to provide over 90% removal for any fuel. It also keeps captured fly ash segregated from captured sorbent, an advantage for plants that market their fly ash. However, this is a more costly approach, with higher capital cost than normal sorbent injection.
- TOXECON-II. This is a newer approach that entails injecting the sorbent between fields of the ESP. Upstream ESP fields capture most of the fly ash and downstream ESP fields capture the sorbent and a small amount of fly ash. This approach can have advantages for power plants that sell their fly ash.

Sorbent injection technology for mercury control from coal-fired boilers has been a very active area of research because the low capital cost of the technology and ease of retrofit make it an attractive retrofit control method. The TSD lists over three dozen full scale field trials on operating electric utility boilers that I am aware of – all but a few having been completed. These tests have been on a wide range of coals and boiler configurations. Some tests have lasted only a few days, some for over 30 days of continuous operation and at least one for over a year. Virtually all of this testing has been in the last five years and most in the last 2-3 years. So, the technology has advanced rapidly over the last few years and experience from just a few years ago may be obsolete. This is especially true when considering the new sorbents that have been developed specifically for use on coal-fired boilers.

Although untreated PAC, as is used in municipal waste incinerators, has been tested and shown to be effective in some coal-fired boiler applications, experience has shown that for most coal-fired boiler applications PAC sorbents that are treated with halogens on the surface of the PAC are much more effective. Unlike untreated PACs, which have a wide range of industrial applications, halogenated PAC sorbents were specifically formulated to address the mercury capture needs of coal-fired boilers. As a result, halogenated PAC sorbents are the current state-of-the-art for most applications and few users would consider untreated PAC for high removal rates except possibly where a fabric filter was installed.

Controlling Mercury from IL Units

It is my opinion that the majority of the coal-fired units in the state of Illinois are capable of meeting the requirements of the proposed mercury control rule at a cost close to that described in the TSD. There is a risk that a small number of coal-fired units in Illinois may not be able to fully achieve the emission requirements required by the rule without additional control technology, operational changes, or other modifications not anticipated in the TSD cost estimate. Because of the different coal types and boiler configurations, not all units will use the same approach.

Most of the boilers in IL fire subbituminous coal. For subbituminous coals, such as Powder River Basin (PRB) coals that are used widely in Illinois, halogenated PAC has been shown to be very effective at several full-scale coal-fired boiler installations providing 90% or more removal. At several sites injection of the halogenated PAC has shown that it provides over 90% mercury removal at treatment rates of about 3 pounds of sorbent per million actual cubic feet of flue gas (lb/MMacf) when injected upstream of a cold-side ESP. This testing includes at least two 30-day continuous trials where 93% or more mercury removal was achieved over the period. This treatment rate for 90% or more removal is equivalent to about 200 pounds per hour of sorbent on a 300 MW plant at full load, or about $180/hour in sorbent cost with sorbent priced at about $0.90/lb. When injected upstream of a fabric filter, as will be possible on a few Dynegy units that, under consent decree, are required to retrofit fabric filters, the sorbent requirements are far less and the mercury removal is even higher. For subbituminous coal, the results of the field trials with halogenated PAC sorbent at various sites have been remarkably consistent from site to site. The consistency of these results from site to site suggests high confidence in the performance on other units firing similar fuels, such as many of the PRB fired units in Illinois. There is a risk, however, that on some subbituminous-fired units the design of the existing particulate control device may limit the injection rate of sorbent due to PM control issues – thereby limiting mercury emissions reduction. But, this risk is likely to be small due to the very low halogenated sorbent injection rates that have been shown to be necessary on PRB fuel fired boilers.

For those bituminous coal units that are equipped with SCR and FGD, they are likely already achieving close to 90% removal or the output based limit of 0.008 lb/GWhr. Those that are not already at these levels of control are close enough that they can achieve the remainder through an optimization method, such as scrubber optimization, or a scrubber chemical additive, which will be a modest cost. Or, these units may use sorbent injection to achieve the very modest incremental reduction needed. Most of the pulverized coal capacity firing bituminous coal that is not equipped with SCR and FGD are firing low to medium sulfur coal. Vermillion will be equipped with a fabric filter in the future. With the fabric filter I expect Vermillion will have very high cobenefit mercury removal – close to 90% - and can readily achieve over 90% removal with sorbent injection. There is also a bituminous unit at Marion that uses CFB technology and a fabric filter. Most likely, this unit already achieves over 90% mercury removal. But, it could easily add sorbent injection to achieve over 90% removal if necessary.

A small fraction of the unscrubbed bituminous capacity fires some high-sulfur coal. But, some of these units (Hutsonville) are reported to be shifting to low-sulfur western coal as they deplete their high-sulfur coal inventories. Full-scale tests have shown that halogenated sorbents can achieve high removal rates on low to medium sulfur bituminous coal, albeit at somewhat higher injection concentrations than for PRB fuels. Combined with some cobenefit removal, 90% mercury removal with halogenated sorbent injection in the range of 6-7 lb/MMacf has been shown on low-medium sulfur bituminous units. For the unscrubbed high-sulfur coal capacity, less mercury removal is likely. However, the unscrubbed high sulfur units are Meredosia boilers

1-4 and are small, low capacity-factor units that are co-located on a site with a much larger unit that fires low-sulfur western coal. The much larger Merodosia #5 should be capable of over 90% removal with halogenated activated carbon. It is possible that Meredosia boilers 1-5 may be able to average under the provisions of the IL rule to achieve the facility-wide target emission reduction. Alternatively, it may be possible for the smaller Meredosia boilers 1-4 to shift to the same low-sulfur coal that is burned in #5, which I expect would address the concern.

There are two units in Illinois – Waukegan 7 and Will County 3 - that are equipped with hot-side ESPs and have not announced plans to install fabric filters. Using a TOXECON system, these units can readily achieve 90% or more mercury removal. Although TOXECON is more costly than a normal sorbent injection system, a TOXECON system offers advantages with regard to PM emissions control, lower sorbent usage, and also segregates the fly ash from the collected sorbent.

Cost of the IL Rule Compared to US EPA's CAMR

US EPA's CAMR rule sets a 2010 allowance cap that requires IL plants to remove about 70% of the mercury in the coal or purchase the equivalent number of mercury allowances. A stricter cap is required in 2018. Because a mercury allowance market does not exist yet and prices are very uncertain, relying on allowances for compliance with CAMR in 2010 is very risky. Moreover, subbituminous units are among the least expensive units to control with sorbent injection. As a result, I expect that most or all of the subbituminous units in IL will install sorbent injection systems regardless of an IL mercury rule. Therefore, the cost of the IL rule over that of CAMR during the period from 2010 to 2018 may be estimated as only the incremental cost from 70% control to 90% control and is mainly the cost of additional sorbent. When comparing the cost of complying with the proposed IL rule with the cost of complying with CAMR, I determined that the state-wide incremental cost of the IL rule over CAMR was roughly $32-$37 million per year spread across all of the Illinois units for the period 2010-2018. In the event that some units require additional or more costly modifications than anticipated in the TSD, the cost difference will be higher.

In 2018 the CAMR allowance cap is such that it will require about 90% or more mercury removal from the coal or purchase of an equivalent number of allowances. Therefore, in 2018 and thereafter the IL rule incurs little or no additional cost of compliance over CAMR.

Costs are Likely to Be Less in the Future

The state-of-the-art of mercury sorbent technology is improving. As discussed in the TSD, there are several emerging sorbent technologies that may improve mercury capture performance beyond what is possible with the currently available halogenated PACs and will thereby reduce the cost of control while improving mercury capture efficiency. New activated carbon sorbent formulations that are designed to address higher sulfur applications will be tested this year. Mineral-based sorbents are also under development and these sorbents are designed to address concerns about the impact of sorbent on marketable coal combustion products. These new sorbents are designed to work with the same PAC injection systems that utilities would install for compliance with the IL rule. So, investments in hardware will not be wasted if utilities switch to newer, improved sorbents that will likely be available in the future. Therefore, it is likely that in 2009 and beyond the mercury removal technology performance will be greater than it is now and the cost will be less than what I have estimated with today's state-of-the-art.

STATE OF ILLINOIS)) SS
COUNTY OF SANGAMON))

CERTIFICATE OF SERVICE

I, the undersigned, an attorney, state that I have served electronically the attached AMENDED TESTIMONY OF JAMES E. STAUDT, Ph.D. upon the following person:

Dorothy Gunn
Clerk
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

and mailing it by first-class mail from Springfield, Illinois, with sufficient postage affixed to the following persons:

SEE ATTACHED SERVICE LIST

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY,

____
Gina Roccaforte
Assistant Counsel
Division of Legal Counsel

Dated: May 19, 2006

1021 North Grand Avenue East
Springfield, Illinois 62794-9276
(217) 782-5544

SERVICE LIST 06-25

Marie Tipsord
Hearing Officer
Illinois Pollution Control Board
James R. Thompson Center
100 West Randolph St., Suite 11-500
Chicago, IL 60601-3218

James T. Harrington
David L. Rieser
McGuire Woods LLP
77 West Wacker, Suite 4100
Chicago, IL 60601

Bill S. Forcade
Jenner & Block LLP
One IBM Plaza
Chicago, IL 60611

William A. Murray
Special Assistant Corporation Counsel
Office of Public Utilities
800 East Monroe
Springfield, IL 62757

S. David Farris
Environmental, Health and Safety Manager
Office of Public Utilities
City of Springfield
201 East Lake Shore Drive
Springfield, IL 62757

Faith E. Bugel
Howard A. Lerner
Meleah Geertsma
Environmental Law and Policy Center
35 East Wacker Drive
Suite 1300
Chicago, IL 60601

Keith I. Harley
Chicago Legal Clinic
205 West Monroe Street, 4th Floor
Chicago, IL 60606

Christopher W. Newcomb
Karaganis, White & Magel, Ltd.
414 North Orleans Street
Suite 810
Chicago, IL 60610

Katherine D. Hodge
N. LaDonna Driver
Hodge Dwyer Zeman
3150 Roland Avenue
Post Office Box 5776
Springfield, IL 62705-5776

Kathleen C. Bassi
Sheldon A. Zabel
Stephen J. Bonebrake
Joshua R. More
Glenna L. Gilbert
Schiff Hardin LLP
6600 Sears Tower
233 South Wacker Drive
Chicago, IL 60606

Bruce Nilles
Attorney
Sierra Club
214 N. Henry Street, Suite 203
Madison, WI 53703

Katherine M. Rahill
Jenner & Block LLP
One IBM Plaza
Chicago, IL 60611