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I. Shirt Sleeve Session - Equipment Suppliers, etc.

The Industrial Boiler MACT rules will be published by EPA in the Federal Register within the next week. Affected units will have 3 years to come into compliance. Owners will have to assess the situations for each of their units that are impacted and, evaluate their options, and come up with solutions in time for compliance.

The initial discussion centered around the coal sampling and analysis that would be required to support EPA compliance tests for such trace elements as mercury. There are 3 accepted analysis methods, including ASTM. The most likely scenario is that the coal supplier would sample and analyze the coal. An ABMA guidance sheet was reviewed. One comment was that more guidance was needed for methods of analysis to be used on these sheets.

A number of older units that have not been through the permit process are now having to evaluate the process. Many of these units will need a dry scrubber and a baghouse to meet the chloride and mercury targets. Although it would be desirable to have a compliance coal, the issues of availability and consistency of supply make that option more difficult. There are many issues such as wet scrubbers vs. dry scrubbers, baghouses vs. ESPs, type of coal, and form of mercury.

The question of stack monitoring, or sampling, was discussed. There are some mercury monitors on the market. These have not been validated over any length of time. There is a method that is semi-continuous that consists of a tube that absorbs mercury. The gas is sampled through the tube over a known period of time and the mercury is absorbed onto the tube. The amount of mercury that is absorbed divided by the sampling time gives the emissions rate.

The chloride issue is somewhat more easily resolved. There are several methods available for removal of incremental amounts of chlorides. One issue is the interaction between the chloride and the mercury. Chlorides aid in the oxidation of mercury in the gas. The oxidized mercury is easier to collect than the elemental, vaporous mercury. Thus a low chloride coal would tend to have higher mercury emissions than a high chloride coal. There is a risk assessment methodology that may allow a higher level of chloride in the fuel on the basis of lower risk. This might allow for some additional mercury control.

With the number of options to be evaluated and a 3-year time frame to come into compliance, it is absolutely necessary to start evaluations now, in order to be ready in time. The order of preference for compliance would be fuel testing first, ash testing second, and stack testing third. The addition of control equipment would be the last resort. It was suggested that we ask the owners what data has been requested by EPA and what types of questions are being asked by EPA.

Many older boilers are not operating at rated conditions due to lack of maintenance. These units will likely need to be overhauled in some way to bring them back to design conditions. The NSR rules that come into play, as well as meeting the MACT rules. There are additional rules such as BART, CAIR, NAAQS, etc. that may impact these units in the future. EPA is also adding pressure for additional reductions in NOx and SO2.

There was some discussion on the guarantees associated with different types of rules. Absolute limits, emission rates, and per cent reductions are all different types of rules that impact emission regulations. Each has its own peculiarities with regard to the type and level of guarantee that can be obtained. EPA is now asking equipment suppliers about how well their equipment will perform. The state permit writers, in particular, are writing this level into the permit. Since MACT is a maximum achievable technology rule, any Asound bite@ that indicates the possibility of high levels of removal can be considered a maximum achievable rate. EPA will take this level and make it the standard. For MACT, cost is not a consideration. The BACT clearinghouse is a case in point. As soon as a low number is put in the BACT clearinghouse database, the agency uses that number as the starting point for the permit.

II. Fundamentals of Industrial Boiler Scrubber Design and Operation - Rod Gravely, CH2M Hill

Aketon is a wholly owned subsidiary of CH2M Hill, which is in the equipment supply business for air pollution control. The physics of scrubbing is based upon the principle that very small particles behave in a manner similar to molecules. That is to say, they exhibit Brownian motion and have a mean distance of motion. Large particles are collected by impaction. They do not follow the stream lines of flow. Gas molecules have a large enough Brownian distance to come in contact with a collector. In between sizes are not large enough to impact or small enough to have a large Brownian distance.

Options for scrubbing include wet and dry scrubbers, as well as dry injection. Reagents include calcium and sodium based additives. Waste products also need to be considered. Wet scrubbers basically spray a solution or slurry into the gas. Usually the liquid is recycled. Make up water is needed to replace the evaporated water and make up additive is used to replace the additive that is used to react with the pollutant. The gas is absorbed in the liquid and then reacted with the additive. Removal efficiencies are relatively high at 95+%. Capital costs are on the high side. Reagent costs tend to be low.

Spray dryers are used in dry scrubbing systems. A slurry is sprayed into the gas stream and evaporated to dryness. The resulting particulates are collected on a baghouse. Some additional absorption occurs in the baghouse. Capital costs are lower, but reagent costs are higher.

Dry injection is dependent upon gas reacting with the solid phase. Down stream particulate control is required to capture the material.

In a generalized way, the dry injection starts with the minimal amount of equipment. As more equipment is added to improve performance and allow for the use of cheaper additives, the complexity and cost increases through the dry systems up to the wet scrubber system. Likewise, reagents that are simple to use are typically costly (ie caustic), while reagents that are low in cost require more complex (and thus costly) systems.

The waste products for calcium based systems are solids that are typically a mixture of sulfates and sulfites. Sulfites are hard to de-water and have no market value. Sulfates are easier to de-water and can be made into gypsum. The ratio of sulfites to sulfates depends upon the amount of oxidation that occurs in the scrubber, but typically is 3/1 in favor of sulfites.

The sodium systems are soluble. The sulfite solutions cannot be discharged. The sulfate systems can be discharged with appropriate pH control.

The decisions concerning what system to use and how these systems are tied into the plant operations are very site specific. This is primarily due to the variation in regulations and costs in each particular area. Most plants have a variety of emissions that need to be addressed. There may be a number of systems that are being deployed, for a variety of emissions control that need to be taken into consideration for the new systems that must be added.

One system for particulate collection is the cloud chamber system. This system uses a cloud of charged droplets for particulate collection, but can also provide some acid gas removal. The theory of operation is much different than that of an ESP. The use of charged droplets was investigated at MIT and EPA in the 1970s. The theory predicted much higher removal efficiencies than for ESPs. Laboratory tests confirmed the theory, but many unsuccessful attempts were made to commercialize the technology. The development needed a robust method to generate the charged droplets. A computer model to generate the design criteria was also needed.

The process gas enters a pre-conditioning chamber where particles are grown and larger particles are removed. The pre-conditioned gas then enters a positively charged chamber where negatively charged particles are removed. The gas then enters a third chamber, if needed, that is negatively charged. Here neutral and positively charged particles are removed. The scrubbed gas exits the system through a mist eliminator. The total gas side pressure drop is less than one inch of water gage. A modular design is proposed. Depending upon the chemistry required in each system, the liquid systems may be combined or kept separate. Systems up to 200 Kw are available.

III. Review of Concurrent Forum Discussions - Fred Fendt, Rohm and Haas, Moderator

Ann McIver reported on the Owner=s Forum. There were 3 major issues discussed by the owners: concerns about the coal supply and availability, relationships with the regulators, and continuous emissions monitoring systems. The biggest challenge for owners is still the regulatory uncertainty. Although the Afinal rule@ is to be issued in the next week or two, there is a likelihood of litigation which will impact the final, Afinal rule@. There is a need for continued R&D on industrial sized equipment. This equipment has to take into account of the variability of the fuels. Lab analysis data will be crucial in the upcoming Boiler MACT implementation. Stack testing is also an issue as some of the methods are particularly complex. Some CEM systems are not compatible with coal-fired plants.

From the equipment suppliers, the fuel analysis and specification issues were discussed. For compliance, these concepts are critical. For something like mercury, it is unlikely that a coal supplier will Aguarantee@ the mercury content of the coal. Owners are looking for performance guarantees. Equipment suppliers need to know the potential ranges of variables and operating conditions so that the equipment can be designed, if possible, to handle the range and still be in compliance. Mercury is a major concern because of the variability not only in the fuel, but also in the operation and type of mercury that is produced in the gas. Forward thinking will be required to look into the potential for all of the other regulatory and operation requirements. The boiler MACT compliance date is 3 years. This is shorter than most people think. Planning has to start now. Suppliers need to be careful in discussing guarantees with regulators, as the regulators have been taking these figures and attempting to apply them across the board.

IV. MACT, CAIR, NOx SIP, NAAQS, and Regional Haze - Scott Mathias, US EPA

Scott is the project leader for the Clean Air Interstate Rule, which is really a collection of rules that cover mercury, ozone, fine particulates, the Interstate Rule, the Visibility Rule, and the Boiler MACT rules. There is a non-road diesel rule as well. The NOx SIP rules started with the 2004 ozone season. There is a Clean Air implementation time line which lays out all of the proposed rules.

The mercury rules proposed to have a cap and trade system that would have a first cap in 2010 and a reduced cap in 2018 of 15 tons/year. There are anticipated to be Aco-benefits@ from additional NOx and SO2 control. An SCR tends to oxidize mercury, making it more collectable. Wet scrubbers will absorb soluble mercury compounds (oxides and chlorides). Baghouses enhance particulate collection of mercury. Activated carbon injection is being tested for mercury control and is targeted for mercury, including elemental vaporous mercury. EPA does not consider this technology to be commercially ready, as yet. However, there is a number of test and demonstration programs underway which should lead to adequate commercial availability.

The Clean Air Ozone rules have been published. The new 8-hour standard has been designated and classifications took effect on June 15, 2004. Implementation plans are due from the states/counties that are impacted. There are 432 entire counties and 42 partial counties impacted. There are 2668 counties that are in compliance. The East Coast, Mid-West and California are the primary locations. The 8-hour classifications are sub part 1, which are in compliance with the 1-hour standard, and in sub part 2 which were not in compliance with either. The sub part 2 rules include the 5 categories of marginal, moderate, serious, severe, and extreme. Compliance for sub part 1 is due in 5 years, with the potential for a 5-year extension. In sub part 2, there are deadlines for each category ranging from 2007 for moderate out to 2021 for extreme. Sub part 1 areas can use RACT, as well as Reasonably Achievable Control Measures. Sub part 2 designations will need vehicle inspections, reformulated gasoline, BACT or MACT, as well as other measures for compliance.

The Fine Particulate Rules will have PM2.5 designations by November with a final rule in the spring. The process has been started with the states recommending 141 counties for non-attainment. EPA countered with 241 counties. The map looks similar to the ozone map except that the Smoky Mountains are in the PM map, along with a small section of Montana, while there are no Texas counties. There are 28 states that are in complete compliance. Compliance is due in 2010, with a possible extension to 2015.

The Visibility Rules had to be re-proposed in April as the original rule of 1999 was remanded to EPA. States must establish reasonable progress goals and timetables to reach natural conditions by 2064. Plans are due by 2008. The BART (Best Available Retrofit Technology) is intended to reduce emissions from large, older plants that may contribute to haze. The BART provisions create a state exemption process using individual source air quality modeling. Control levels for SO2 and NOx from EGUs for all plants over 250 MW. There is an option for a state to propose Abetter than BART@ rules to avoid a source-by-source evaluation. SO2 control at 95% is specified. The NOx level is 90% or 0.15 - 0.20 without SCR. Natural conditions have been modeled by EPA and guidance has been given to the states to help with the interpretation of the modeling to set specific targets.

The Clean Air Interstate Rules are proposed to avoid non-attainment in states other than the state of origin. The geographic scope is based on air quality impact of SO2 and NOx from individual states on down wind, 8 hour, PM and ozone standards. As a result, annual emissions caps for both pollutants were established at an additional 65% SO2 removal and a NOx equivalent of 0.125 lb/MMBTU. The states will provide the flexibility as to how these reductions will be achieved, which will in turn determine whether or not industrial units are covered by the rules. Two phases of reductions are proposed due to limitations on construction labor for pollution control (2010 and 2015). SO2 emissions would be capped at 2.7 million tons/yr in 2015 and NOx emissions would be capped at 1.3 million tons/yr in 2015. The CAIR adds 6 states to the NOx SIP requirements.

IV. State Implementation Plans for Industry - Patricia North, NH Dept. of Environmental Services

Pat noted that the final rule for the Boiler MACT has not been published in the Federal Register as yet, so there are no final dates for compliance. However, they are expected imminently, so roughly 3 years from next week is a good estimate. The MACT floor for existing sources is the best performing 12% and for new sources as the best practice at a similar source. A major source is any source that emits 10 tons/yr of any HAP, or 25 tons/yr of total HAPs. Waste heat boilers are not covered under this MACT unless they are supplementary fired with more than 50% of the heat input. Units that burn hazardous waste or other restricted materials are under a different MACT. Hot water heaters and temporary boilers are also excluded. R&D units (used only for development and testing) are also exempt. EPA estimated that there would be 58,000 boilers and process heaters that would be covered by this rule with an additional 800 boilers in the next 15 years.

There are 4 categories of HAP B mercury, non-mercury metallic HAP, inorganic HAP, and organic HAP. The surrogates for these 4 HAPs are PM for non-metallic mercury, HCl for inorganic

CO for organic, and mercury for mercury HAP. For PM there is also a substitute metals list of 8 metals that can be utilized. There are large and small units, new and existing units, and solid, liquid, and gaseous fuels. There is also a limited use category. Testing and compliance will require initial and annual stack testing or fuel analysis. Selective operating parameters will need to be monitored during compliance tests. Testing must be done at maximum load with the equivalent of the worst case fuel. If after 3 years, the units are in compliance, the stack test can be moved to a 3-year cycle. Continuous compliance requires monitoring the site specific operating limits of the plant. Compliance reports are due semi-annually. There are health based compliance alternatives that may provide a potential compliance method. Health based impacts are based upon site modeling. A Alook up@ table is available for HCl and Manganese. Certain units are only subject to notification new small gaseous units and existing small units.

V. Particulate Control Technology for Meeting Industrial Boiler MACT - Brad Rogers, BHA Group, Inc.

A baghouse can capture mercury as well as particulates. However, the bag itself does not collect the mercury. The filter cake collects the mercury, as well as the fine particulates. Thus building up an adequate filter cake, at the expense of gas side pressure drop, is key to good removal. Some LOI on the ash is helpful for mercury emissions, although this represents a loss in combustion efficiency. At the moment, mercury in the ash is not considered a hazardous waste. Low flue gas temperatures help the collection of both mercury and particulates. On the other hand, there could be SO3 condensation that may be a deleterious effect on bag life. A new approach is to put electrodes between the bags. This combines the effects of an ESP with a baghouse. This technology is being licensed from EPA.

VI. Application of Wet ESPs For Meeting MACT and PM2.5 - Buzz Reynolds, CR Clean Air Technologies

Buzz noted that as particles get smaller, electrical effects become stronger than mechanical effects. Vaporous metals tend to condense on the finer particles as the surface area of the fine particles is on the order of 10 times greater for the fine particles. In comparing wet and dry approaches, the wet systems have a smaller foot print (higher velocity, lower temperature, lower pressure drop) than the dry systems (low velocity, higher temperature, higher pressure drop). The disadvantage for wet systems is the wet by-product. Wet ESPs are actually older technology than dry ESPs. They have been used extensively in the sulfuric acid industry. There has not been much call for these units in coal-fired power plants. However, with the new fine particulate regulations, the finer particles may drive the application. There are no moving parts in a wet ESP. The particles never really reach the electrode and are constantly washed away by the water flow. Configurations can include plate or tubular construction. Test results indicate that PM2.5 of up to 99.9% along with acid gases such as chlorides and SO3. Oxidized mercury has been capture toward the 80% level, while 20 - 40% of the elemental mercury appears to be further oxidized and captured. Additional SO2 removal has also been observed. The wet ESP is intended for polishing service after the dry ESP and wet scrubber. Beside some ore processing units, there is a pilot unit at the Bruce Mansfield station (First Energy) that is DOE funded. Several series of test have been run. The test results ranged from 93 - 96% removal on PM2.5 and 88 - 92% on SO3. Mercury was also measured. On the order of 95% of the particulate and oxidized mercury was captured and 18% of the elemental mercury, yielding a total mercury reduction of 78%. One of the potential modifications is to retrofit the last field of an existing ESP. EPRI conducted some tests in the 90s showing a 95% collection of fine particulates, with additional collection of SO2 (20%), HCl, (35%), and HF (45%). Plasma enhancement will be added to give additional opportunity to oxidize some mercury. A 5000 ACFM pilot of this system is being tested at Southern Co.=s Plant Miller. They are hopeful that this type of retrofit can be successful, especially for those that have limited space for new equipment, at a cost of about $30/Kw.

VII. Mercury Control and Baghouse Operations - Will Goss, RJM Beaumont

The goal of the DAP (dry absorption process) process was to develop a multi pollutant emission control system that could be upgraded as emissions regulations change over time. Mercury, chlorides, particulates, metals, SO3, SO2, and other pollutants can be considered. It is known that a baghouse and lower gas temperatures will be needed for fine particulates and mercury capture. A duct injection system (flash dryer) is used for acid gas collection and gas temperature reduction. A baghouse is used for the particulate control. There is an interaction between SO3 and HCl when both are present. The duct reactor takes recycle material that can be pre-treated with water to achieve a certain moisture content, but essentially a dry material. The duct is made from ordinary grade carbon steel. A one second residence time is designed for the gas. The preconditioned gas goes into a baghouse for particulate collection. A pilot plant test unit is available at SRI that can be used to test specific fuels. The additive for SO2 control is lime. The preferred gas temperature is above 200 F. A pulse type bag filter is utilized with side inlets for the gas and specially designed hoppers. Bag placement is modeled in order to optimize the distribution of gas and solids to assure that an adequate cake is generated during operation. With SO2 control, some of the solids are recycled back to the dry absorber, such that the inlet dust loading is higher than a normal baghouse. Costs range from $30 - 50/Kw (no foundations, ductwork, fans, or demolition work). The range of costs on small units ranged from $50/lb steam to $15/lb steam for industrial units ranging from 50 kpph - 300 kpph.

VIII. A Comparison of Wet and Dry Scrubbing Systems for Industrials - Sam Barnes, Cummins & Barnard

Dry scrubbers are generally lower in cost than wet scrubbers. Usually a higher quality reagent is required. A particulate system after the scrubber is required. The removal efficiency is not as good as on a wet system. The wet systems have 3 subsystems and are more costly than dry systems. The reagent is much less costly. The O&M costs are higher as well as there is additional material handling involved. Materials of construction require higher alloy or coated steels. A wet ESP can handle the PM2.5, HCl, HF, and SO3. A demonstration at Presque Isle station (3x90 MW) is being funded by DOE and WE Energies (Formerly Wisconsin Electric). At French Island there will be a unit with a dry scrubber with an SNCR system.

IX. Experience with Industrial Scale Dry Scrubbing - Byron Nichols, Virginia Tech

The system at Virginia Tech has been in operation for 5 years. The unit is on the main campus. The supplier was Procedair. They have a chain grate stoker of 100,000 lb/hr. A PLC controller is used to control all of the systems. Flue gas from the boiler goes into a venturi type, duct reactor. Lime is the additive. A bag filter is deployed for particulate collection. The hoppers are set up to recycle the ash to a venturi reactor. Ash is bled from this system for disposal. The mixture of the lime and ash is hydrated for reaction purposes.

The inlet damper creates the pressure drop to regulate the system. Electrically driven dampers gave a lot of operational problems, especially if the unit experiences a lot of shutdowns. The damper is currently set manually. There is a dilution damper that allows for gas recirculation to maintain gas flow when needed. The compressed air supply is critical for operating the baghouse. Assuring that this system is reliable is to be sure that there is no oil or particulates in the compressed air. The water supply is city water. The hot solids are quenched down from 320 - 340 F to 40 - 70 F. A feed forward control system is needed to provide the correct quantity of water at each boiler load. The flow rate range from 1.5 gpm to 6 gpm. The conditioning drum mixes the lime, the recycle ash, and the water. The mixing nozzles are very fine and any debris can plug a nozzle. Periodically the drum has to be cleaned as lime tends to deposit on the walls of the drum. The chain drives have been broken when appropriate cleaning has not taken place. The venturi reactor is sensitive to velocity. The reagent flow and reagent quality is important. The pick up for the lime requires adequate air flow to move the material. During the last year, a somewhat finer lime was received. This material tended to pack up and penetrate some of the instrumentation. The baghouse consists of 5 compartments. The cleaning cycle is controlled by differential pressure. When there is a plugged compartment, the pressure drop goes to zero. There is an outlet valve leaving the compartment. There is no perfect seal valve at this point. If the compartment needs attention, the valve must be blocked to avoid in-leakage of air. The ID fan and the variable speed drive have to work in order for the system to operate. Good quality equipment is a necessity. Maintaining a clean area, especially for the motor control center is important to avoid electrical shorts, etc. The baghouse isolation damper needs to be checked frequently to avoid back leakage of acid gases that could cause corrosion problems. The back pressure damper needs to be exercised so that it does not freeze up. The recycle damper provides flue gas recycle to maintain proper gas flows for the reactor. The fresh lime rotary air lock provides the air to move the lime. Dry air is needed to avoid problems. The reheat coil provides heat back into the flue gas to protect the existing stack. There is a dump rotary air lock for the excess ash. There is an air blast that periodically cleans the rotary system. This cleaning must occur routinely in order for the air lock to work. System waste silos and hoppers need to be kept flowing. The overall system performance has been very good. The permit level was 92% removal. The system readily attains 96% removal. The CEM system does not record below 2% for opacity and this is readily attained.

In summary, baghouse operation adds to complexity, operator training is critical, preventive maintenance is a necessity, reagent quality is important, and consistent operation is very helpful.

X. Multi-Emissions Scrubbing for NOx, SOx, and Hg - Charlie Hammel, EnviroScrub Technologies

EnviroScub offers the Pahlman Process for multi-emissions scrubbing a range of pollutants in one device. This is a sorbent based process where the sorbent is regenerated. Air Cure, Nooter/Eriksen, and ELTech are partners. A test system was deployed at DTE Energy=s River Roughe station to a skid mounted unit. The skid runs up to 2500 DSCFM (about 1 MW). The scrubber was also tested at Minnesota Power=s Clay Boswell station. Both NOx and SOx were captured at high levels. The mercury capture was 67% on PRB coal. A newer sorbent was used at River Rouge. The SO2 removal was 99.8% and the NOx removal was 98%. They thought that 97% of the oxidized mercury was captured. Renewed testing at Clay Boswell gave 99% SO2 removal and 95% NOx control. The mercury capture was in the high 90s for the oxidized mercury and in the 80s for the elemental mercury for an overall capture of 94%.

The sorbent is a patented formulation of manganese dioxide and other oxides of manganese. High surface area is key to good performance. The material is low bulk density and porous. There are a number of naturally occurring crystals for the oxides. These occur in nodules on the ocean floor, where they perform a clean up process by absorbing heavy metals from the sea water. The precipitated oxides are set into an octohedral structure. The goal is to provide nanofibers with tunnels in the structure such that the desired pollutants can be adsorbed into the system. The goal is to get a high loading of SO2 or NOx onto the sorbent.

The acid gases are absorbed and capture as sulfates, nitrates, and chlorides. The sorbent is sprayed as a slurry into the flue gas after the particulate removal. The gas is then sent to a second baghouse to collect the material. Water is added to dissolve the manganese salts. The solution is oxidized to bring the manganese to its highest oxidation state. The pH is increased to precipitate out the manganese dioxide. An electrolytic cell provides the oxidant. Various salts such as sodium, potassium, or ammonium sulfate, chloride, or nitrate can be used. Chlorides are removed from solution with a carbon filter. A study was conducted for a utility to estimate costs. The capital cost ranged from $184 - 212/Kw. Operating costs were about $3.50/Mwhr. No credit was taken for by-products.

XI. Multi Pollutant Treatment of Gases and Particulates with Cloud Chamber Technology - Rod Gravley, Aketon Technologies, CH2M Hill

The CCS technology uses a pre-conditioning chamber where particles are grown. Large particles are removed and gas cooling occurs. The gas velocity is about 10 ft/sec. The pressure drop is about 4 inches water gage. The second chamber imparts a positive charge to the droplets. The chamber is a large empty chamber with low velocity and low pressure drop. A third chamber with negative charge can be utilized if necessary. This system was developed for very fine particulates for which no other methods were available. The system can also clean gases as well as particulates. The difference between a cloud chamber and an ESP are as follows:

No particles are charged

Efficiency is not a function of the particle number density
The collector drops go to the particles rather than the particle moving to the wall
There is low power consumption
Efficiency is not a function of the electrical resistivity of the particle
Gases are removed by the water drops as well as particulates

The technology derived from observations that the air is rather clean after a thunderstorm. There are obviously charged drops in a thunderstorm. This lead to modeling of charged drops and their performance in collecting particles. From single droplet efficiencies a scrubber efficiency can be estimated using residence time and liquid to gas ratios for performance. Typically soluble alkalis will be used for acid gas capture. Roughly 7 - 8 watts per 1000 acfm are required to charge the drops. The L/G is 10 - 15 gpm/1000 acfm.

XII. EPA Monitoring Requirements - Louis Nichols, US EPA Clean Air Markets Division

The Clean Air Markets Division is the Acap and trade@ group within EPA. The cap and trade program allows emitters the flexibility to decide where, how, and when reductions should be made. In order to maintain the economic and environmental integrity of the system, valid monitoring of emissions is required. Since 1994, emissions from large electric power plants have been measured by sources and reported to EPA for SO2, NOx, and CO2. SO2 emissions have gone from 17.3 million tons/yr in 1990 to 10.2 million tons/yr in 2002. The banking provisions have allowed some excess emissions to be covered in recent years without getting into violation situations. The NOx budget program concerns the ozone season and includes industrial sources. In the OTC program, the Eastern US has remained under the 200,000 ton/yr level compared to the over 500,000 ton/yr in 1990. The price of allowances is under $1000/ton at the present time.

Comprehensive quality assurance for monitors is critical. A complete accounting of mass emissions is required in order to match up allowances and emissions. The system is all electronic and results are posted on the web. Quality reviews are done by software to check for daily calibrations and periodic tests. There are ad hoc software checks and targeted field audits. These programs are intended to find problems early so that fixes can be applied without enforcement proceedings.

Quality assurance tests include the relative accuracy test audit (RATA), the bias test, the quarterly linearity check, and the daily calibration check. There are some options to stack monitoring such as fuel monitoring, when the fuel composition is known to be uniform and the fuel is easily measured. PEMS systems can also be used. The source installs and maintains the system. The system reports hourly to EPA. EPA audits the results and communicates with the system. For SO2, 36% of the units use CEMs and account for 96% of the emissions. For NOx, 87% of the units use CEMs and account for 99.9% of the emissions.

The compliance record has been excellent. In the acid rain program, only 15 excess emissions penalties were issued over the 9-year program. In the NOx budget program, only 24 excess emissions were issued. In the NOx program, the penalties are tied to the next year=s allowances. In this case, 3 allowances must be surrendered for each ton of overage going into the next year. These do not constitute violations in the sense that they trigger enforcement proceedings. Only 8 enforcement proceedings were needed and most of those were for failure to install a CEMS where required.

XIII. Continuous Emissions Monitoring Panel - Bob Davis, Scott Specialty Gases, Inc., Moderator

The panelists included Ron Jernigan with ThermoElectron, Ty Smith with CEMTEK, Michael Hartman with Air-Tech Environmental, as well as Bob. Ron reported on the potential for low cost ownership of CEMS. Since 1993, over 3000 CEM systems have been installed by the Utility industry in order to comply with the very strict Part 75 requirements. One key factor in system selection is the sample acquisition system. There are two different approaches, basically a dilution/extraction system and a direct extraction system. Particularly for SO2, the dilution systems require much less maintenance. This is especially true for coal-fired units. In the case of direct extractive systems, thermoelectric sample gas moisture removal chillers are preferred over refrigerant systems. Also external particulate filters are easier to maintain than in stack filters. Clean, dry air is critical for a well functioning CEMs. Since CO2 is a required measurement, all CO2 must be removed from the incoming air. The most common SO2 monitor is the UV Fluorescence (85%). The most common NOx monitor is the Chemiluminescence (96.4%). For CO2 the NDIR is still the preferred system (100%). For oxygen the paramagnetic system is preferred (87%). The flow rate measurement is now done primarily by ultra sonic techniques with 62% of the monitors. Differential pressure was the standard and has about 30%. Experience in the Utility industry has clearly shown that the lowest cost of ownership is not correlated with lowest initial cost.

Ty Smith reported on considerations for new CEM systems. The MACT rules will likely require monitoring systems for one or more species. Local regulations and permit requirements also need to be considered. In many cases, process data may also be desired. Opacity may also be a part of the monitoring system. Site information is the starting point for the design and set up of the system. This data has to be accurately conveyed to the CEMs supplier. Information such as ambient conditions, sample points, instrument locations, data acquisition, and maintenance schedules will all be needed. Sample ports located near the sample point locations are necessary for both the CEM system as well as the independent verification tests. Additional considerations include support, gas pressure, interfering gases, moisture content, fuels, ammonia injection, and temperature. Planning ahead is a good idea and future requirements should be considered. A monitoring plan should be laid out. Training of operators and maintenance personnel will be required. Once the system is installed, the system must be certified by an independent 3rd party. Compliance testing and annual testing will be required. Spare parts for the system are very important. Most trouble shooting is done by part replacement. Identification of key spare parts is critical and part availability needs to be verified. Technical support for the software is just as necessary for these systems as other IT. Upgrades, licenses, fees, etc. are all part of the system. Maintenance and support contracts should be considered. For opacity monitors, purge air and blowers need to be considered. It is a good idea to have weather covers and an on site set of audit lenses. Calibration gases need to be on site and managed carefully. Spare bottles, inventory, and delivery all need to be organized and controlled.

Mike Hartman reported on experiences with source testing. This is primarily stack testing. Diagnostic sampling is a specialty for problem issues. A case study in point was a system that had high NOx and a high ammonia slip. Ammonia is supposed to react with NO to form N2 and water. However, ammonia is very soluble in water. Low temperature condenses water and scrubs ammonia. This fact needs to be considered when sampling the system. For an extractive system, the temperature must be kept over 250 - 300 F. At the SCR, the temperature level is more like 700 F. The sampling should be continuous. The results should be available on site. That eliminates taking a sample and Asending it out@. Duct pressure and size is important. For large ducts, long probes are needed. For pressurized ducts, sampling valves are required. A sampling matrix is needed for diagnostic results. In order to make an ammonia measurement, it is desirable to convert the ammonia in the sample into NOx. The sample stream is split into 2 fractions. The first one is measured as is for NOx, while the second one has the ammonia converted to NOx and measured. The ammonia is determined by difference. The ammonia conversion is accomplished in a stainless steel line with a catalyst. Oxygen must be present for the conversion. Along with the concentration measurements, flow measurements are required. A hot wire anemometer is preferred for accuracy. It is necessary to have the device calibrated at the temperature range that is intended. The wiring in the anemometer needs to be cooled to protect the insulation. In the case study, the flow was low at the edges and high in the middle. The gas flow was being blocked in certain areas to the extent that 30% of the catalyst was not being utilized. This impacted the life of the remaining 70% of the catalyst. At start up, the unit could make its NOx emissions and ammonia slip. Over time, the catalyst in the center became exhausted so that the ammonia was no longer reacting with the NOx, resulting in high NOx and high ammonia slip. The material that was blocking the flow was removed and the situation improved. The ammonia injection system could also be adjusted from the results of the data.

Bob reported on the protocol gases that are used for calibration. Calibration gases are supposed to be accurate to within 2%. In blind audit tests, nearly half of the calibration gases failed this standard, some by as much as 6%. Inaccurate calibration impacts the system both ways. If the gas is higher than the tag level, the site will under report emissions and be subject to fines. This is not the most common situation. If the gas is lower than the tag level, the emissions are overstated. This is more common as the contents of the bottle tends to degrade over time. In this case, a unit that is trading allowances is losing the value of the credits. The calibration gas should be a protocol gas that has a traceable standard. The range of values needs to be carefully considered. Some gases are not available at the concentrations that are desired. There are no protocol gases for ammonia and HCl at the present time. Zero gases also need to be checked. The use of ordinary nitrogen bottles may not qualify as a Azero gas@ to meet all EPA requirements. Another consideration is whether or not all components are in the same gas bottle. When CO2 is present, the average molecular weight of the gas is increased. This changes the dilution level in a dilution system where the gas goes through an orifice. As a minimum, make sure that the EPA audit uses the same type of gas that the site used. Care needs to be taken in the sampling line when acid gases are present. Cold temperature conditions can impact the gas bottle, particularly when low volatile materials condense. If this occurs, move the cylinders inside into a warm enclosure. Cylinders can be rolled to help remix the gas. Never, ever heat up a cylinder. Another issue is the expiration of cylinders. Vendor tracking of cylinders is very helpful. On site inspections will work, but are often expensive. Certificates for these cylinders should be available on line. During an audit, certificates are a required part of the verification. The ICAC has a list of requirements for calibration gases on their web site. EPA has 14 points on a certification. **XIV. EPA=s Environmental Technology Verification Program - Andrew Trenholm, Research Triangle Institute**

There is a New & Emerging Environmental Technologies database available on the web. The address is http://neet.rti.org. The system should be fully up and running within the next month or so. The Environmental Technology Verification program (ETV) has a goal to accelerate new environmental technologies into the market. The objective is to verify performance of commercially ready environmental technologies using objective and quality assured data resulting in the publication of verification statements for the technologies. The program is voluntary. There is a web site for this program as well. Test protocols have been completed (or in process) for paint overspray arrestors, baghouse filter products, NOx controls (including emulsified fuels), dust suppressants, mobile source retrofits, and biofiltration systems. The baghouse filtration products protocol covers performance for all baghouse filtration products. The initial focus is on bag fabrics and the removal efficiency for PM2.5. The procedure has been adopted as ASTM D6830. Potential areas of application include woven fabrics, membranes, bonded, and ceramic materials.

Mobile sources are seeing increased attention as the emissions from diesel engines are being recognized as an important source. Innovative technologies are needed. SIP credits are available through EPA under the voluntary diesel retrofit program (VDRP). Technologies under consideration are diesel oxidation catalysts, PM filters, crankcase vent filters, and engine modifications. A test approach is being developed based upon the federal engine dynamometer tests. NOx, PM, HC, and CO are measured. Accelerated testing is considered. There have been 5 completed verifications. Under the VDRP, there will be voluntary SIP credits for stationary diesel engines for particulate matter. There are grants available from EPA SBIR and various states to promote the development and commercialization of new environmental technologies. ETV can partner with users or user groups that can provide better input on the user requirements for specific technologies.

XV. Consolidating Industrial Power Plant Compliance - David Wall, Trinity Consultants

David noted that environmental management information systems (EMIS) can be used to help consolidate all of the different environmental compliance activities that may be required at a plant. Under MACT, operating limits are established for a variety of control equipment. These may be flows, pH, pressure drops, emission rates, etc. These data have to be recorded more or less continuously to demonstrate that the unit is in compliance. Any malfunctions have to be recorded and reported. SSM plans must be kept at the plant. Title V permits necessitate generate of additional reports including semi annual reporting. Under Title V, certification of compliance is required. An EMIS can help remind, comply, simplify, match, predict, and assess environmental issues. An EMIS can interface with existing plant data systems as well as tied into new and/or manual data input. There are 3rd party licensed software systems available, but custom designed systems can be set up. For more specific issues, PDA (hand held) type systems may be appropriate. Some of the benefits of hand held systems are minimization of human error, completeness of input, and simplification of record keeping. These can be tied into existing databases via synchronization routines. Malfunction reporting ranges from a paper form to an automated, custom designed system. In such a system SSM procedures and changes can be tracked and recorded automatically. With the automated system, the corrective action plan is automatically displayed to help determine whether or not the plan was followed. This is recorded along with the duration, etc. This is important because there is some relief on exceedance issues if the corrective action plan was followed. Task tracking can be set up in calendar format. The final goal is to assess if your are doing everything that you are supposed to be doing, being able to prove that you are doing everything you are supposed to be doing, and making sure that all of your required documentation is in order. Upkeep and updating is a key factor for success. Training becomes critical to assure that this takes place. There are also web based services that do not require tie in with host company IT systems, but allow direct input via a web connection (hand held or otherwise).

XV. NOx Emission Control Technology - Henri Reiher, ABMA, Moderator

The panel consisted of William Testa of Todd and Gerry Hamilton of Cohen, as well as Henri. William reported on a number of low NOx burner systems. A number of refinery applications have required either VOC gases or hydrogen content fuels to be combusted along with auxiliary fuels. These were blended in a long duct system prior to mixing with gas turbine exhaust and combustion ahead of the HRSG. In one application, a very low NOx specification (<9 ppm) was required. A Rapid Mix burner with flue gas recirculation was used with a feed forward signal to control the FGR. Gerry reported on the ultra low NOx burner systems supplied by Coen. These are gas, or refinery gas, fired. Again, less than 9 ppm NOx was required. Fuel flexibility provides users with the potential to reduce the total amount of natural gas consumed. Henri reported on the integration of the Cleaver Brooks family of boiler companies including Natcom, Industrial Combustion, and Nebraska. The Natcom technology relies on a center core air zone, a swirl zone, and secondary air zone. There can also be a Ahypermix@ steam injection to increase the mixing beyond the main core. This technology has been applied for forced draft burners in sizes ranging from 1 - 63 MMBTU/hr.

XVI. Developments in Oxygen Assisted Combustion – Leonard Switzer, Praxair

Oxygen can be used to assist the combustion process in a variety of ways including emissions, efficiency, and throughput. By virtue of more rapid and complete combustion, it is sometimes possible to increase throughput and fuel efficiency for the same equipment. Oxygen assistance produces higher flame temperatures, which in turn could lead to increased NOx formation. The location of injection and the potential for internal recirculation can be used to circumvent this problem. Burners that are used in a glass furnace allowed these systems to increase production while reducing emissions. In the case of the glass furnace, the oxygen cost came out to $7.40/ton of glass. While the fuel cost savings alone were not sufficient, there were additional savings from the increased production (capital) and reduced emissions (allowances and capital). In coal-fired boilers, small amounts of oxygen injection at the burner tip can provide up to 40 - 50% reductions in NOx emissions. A special burner has been developed to co-fire biomass in waste to energy plants. A high velocity hot oxygen stream is used to atomize and ignite very difficult to burn fuels. Sludges and biowaste are candidate fuels for this burner. An advanced concept is the oxygen transport membrane (OTM) boiler. In this process, the membrane separates the oxygen from the air and is used to fire the boiler. This gives the opportunity to produce a concentrated stream of CO_2 as well having a very efficient boiler with low emissions. This development has been centered around gaseous fuels. In general, oxygen assistance is very site specific in its benefits, thus requiring a site specific analysis for each application.

XVII. Cost Effective Low NOx Retrofit Technology for Industrial Boilers - Erwin Penfornis, Air Liquide

There are about 25,000 gas-fired boilers between 10 and 100 MMBTU/hr, of which some 50% are in non-attainment areas. The new ozone rules and the CAIR rules will raise the number of units that will need additional NOx controls. Air Liquide is developing a pulsing combustion system which creates alternating fuel rich and fuel lean zones. In a fire tube boiler, or other more compact units, the residence time may not be sufficient for complete combustion. As a result, a Apost combustion@ addition of oxidant is used to complete the combustion. This could be air or oxygen enriched air. NOx reductions range from 35 - 60%. The retrofit is fairly simple in that no burner replacement is needed. A pulsing device on the fuel input is added, with the oxidant system if needed. The lower investment cost and relatively low operating cost lead to a 50% evaluated cost benefit compared to retrofitting low NOx burners.

XVIII. SCR and SNCR for Industrial Facilities - Sean McMenamin, Peerless, Moderator

The panel consisted of Richard Abrams of Babcock Power International and Kevin Dougherty of Fuel Tech, as well as Sean. Richard reported that Babcock Power has a technology exchange agreement with Babcock Borsig in Germany. Babcock Power claims to be the market share leader (at least in number of installations) in the US. The SCR technology uses ammonia injected into the flue gas to react with the NOx. Uniform distribution is critical to successful operation. Babcock uses static mixers in the duct work to uniformly mix the flue gas as well as the ammonia. These mixers are static discs that are located in the ductwork at an angle. This allows for the reduction in the number of injection points that are required to achieve relatively uniform distribution. This also allows for reduced tuning of the injection grid on startup. They refer to these discs as Adelta wings@. Cold flow models are still done for every job. These models are made and tested in Germany. Cross mixers are used to mix flow across a duct including temperature. Pressure drop associated with these systems is on the order of 2 inch water gage. The advantage of a more uniform flow is that somewhat less ammonia can be used, resulting in reduced ammonia slip and resulting ammonium bisulfate formation. Somewhat less catalyst can be used or additional catalyst life can be realized. Ammonia can be supplied as anhydrous, aqueous, or as urea. A full SCR system tends to be expensive. Alternatives are a compact Ain duct@ SCR, a hybrid cascade system that uses SNCR and SCR together, and a tail end system. The In-duct SCR system has recently been installed on a gas fired, Riley, Turbo boiler at Exelon=s Handley #3. The requirement was for 94% NOx reduction. A duct expansion under the economizer hopper was used with a series of delta wings to accommodate the gas flow from the split back pass system. The ammonia slip was less than 3 ppm with greater than 94% reduction.

The hybrid system uses the SNCR system without regard to ammonia slip at the SNCR location. The Aslip@ is handled at the SCR location which acts as a polishing system for additional NOx removal. The tail end system operates on clean gas with a lower inlet gas temperature. However, the catalyst still needs a higher gas temperature to operate. A gas/gas heat exchanger is used to recover some heat along with duct burners to bring the gas up to temperature. These systems tend to be expensive. Babcock Power is developing a system called the RSCR that is attempting to reduce the cost of tail end systems significantly. This system uses a combination of different catalyst, more efficient heat exchange, and the static mixers to help reduce costs.

Kevin reported on SNCR for industrial facilities. Fuel Tech has a family of technology starting with NOxOUT, which is an SNCR technology using aqueous urea injection. Ammonia based systems are available as well as cascade systems, rich reagent injection, and fuel lean gas reburn. On some units, especially those with low sulfur, reductions up to 74% are possible as a higher ammonia slip can be tolerated. The NOxOUT Cascade system combines the SNCR with a smaller SCR to give about 60% reduction for SNCR and 40% reduction from SCR for a combined total of 76% reduction. SNCR systems are low capital cost systems that can reduce NOx for less than $2,000/ton. The system provides some flexibility in that the system can be turned off when NOx abatement is not required. Fuel Tech offers allowances as part of their guarantee to provide additional comfort to the user.

Sean reported on the issues of ammonia slip and NOx that escape the reduction system. AImperfections@ in the system lead to gas mal distribution, ammonia distribution issuses, mixing problems, and system sealing/leak issues. The upstream conditions provide the starting point for the gas flow profiles. Corrective devices include perforated plates, turning vanes, and airfoils. CFD modeling is used to evaluate the performance of these devices. A grid device is used for ammonia injection. These are tubes running across the duct with holes in them. It is desirable to have the mole ratio of ammonia to NOx equal to 1.0 within 5%. Another issue is seals and leaks. There are 2 types of leaks. The first type occurs between 2 catalyst modules. In order to minimize this leak, frames are designed with a pull mechanism to bring the catalyst close to the frame. The second type is the side of the catalyst frame against the duct walls. Seal plates are utilized that stab into the insulation to reduce this leakage. Cutting down on leakage improves performance and minimizes losses of ammonia. One interesting application was a refinery case with a boiler exhaust that was too cold and a refinery exhaust that was too hot. The gas streams were mixed to provide a gas stream of the right temperature. The only difficulty was that the duct length for mixing was too small. Flow controls were needed to provide the appropriate mixed mean temperature.