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FLUE GAS CONDITIONING FOR IMPROVED PARTICLE COLLECTION IN ELECTROSTATIC PRECIPITATORS

Quarterly Technical Report

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INTRODUCTION

Electrostatic precipitators (ESP) serve as the primary air pollution control device for the majority of coal-fired utility boilers in the Eastern and Midwestern regions of the United States. Since most of these ESPs are collecting flyash generated from medium- and high-sulfur coal, they are not experiencing operational limitations which are common when treating high-resistivity particles and are performing at an efficiency that is as high as could be expected.

However, there are indications that the collection efficiency could be improved with flue gas conditioning. Conditioning is commonly used for solving operational problems associated with high-resistivity dusts. The purpose of conditioning for low- and moderate-resistivity applications is to increase the adhesive characteristics of the dust. Flue gas conditioning that increases particle adhesion has the potential to improve collection efficiency because a large percentage of particulate emissions from a well-performing ESP is due to reentrainment. Improved ESP performance should result if particle reentrainment could be reduced by making the particles more adhesive. This could produce a significant reduction in emissions from an ESP from the following mechanisms:

- Reduced erosion-type reentrainment
- Reduced rapping emissions
- Reduced hopper reentrainment
- Increased agglomeration of fine particles

A flue gas conditioning system would have several advantages as a retrofit technology for ESPs. Because it would require no modifications to the ESP, it would be very cost effective. Flue gas conditioning systems that are currently available are relatively simple and can be applied to almost any ESP. The installation would require minimal downtime of the boiler. Finally, it could also be used on new ESP designs to provide high collection efficiency with a reduced collection area.

PROGRAM OBJECTIVES

The purpose of this research program is to identify and evaluate a variety of additives capable of increasing particle cohesion which could be used for improving collection efficiency in an ESP. A three-phase screening process will be used to provide the evaluation of many additives in a logical and cost-effective manner. The three step approach involves the following experimental setups:

1. Provide a preliminary screening in the laboratory by measuring the effects of various conditioning agents on reentrainment of flyash particles in an electric field operating at simulated flue gas conditions.

2. Evaluate the successful additives using a 100 acfm bench-scale ESP operating on actual flue gas.

3. Obtain the data required for scaling up the technology by testing the two or three most promising conditioning agents at the pilot scale.

The objectives of this program will be attained by successfully completing the following technical tasks:

Task 2. Selection of Additives

The first technical task will identify additives that could be used as flue gas conditioning agents for ESPs. In order to provide a more thorough coverage of potential conditioning agents, the search will include products that were not specifically designed for ESPs. Candidate additives cover a range of chemicals and include surfactants, adhesives, polymer resins, foams, and emulsions. These products will be reviewed to determine which ones are likely to survive and function in a flue gas at 300 ^{o}F.

Task 3. Initial Screening of Conditioning Agents in the Laboratory

Since several flue gas conditioning agents will be evaluated as part of this program, and since each additive will require testing at different concentrations and flue gas conditions, it would be desirable to screen the additives in a cost-effective manner. The screening must be performed such that experiments focus on the primary parameter of interest, which in this case is the adhesion of particles in an electrostatic field.

In order to evaluate how flue gas conditioning affects a particle in an electric field, it is necessary to study the behavior of particles in an electric field. A laboratory flue gas simulator and injection chamber will be used to produce a conditioned flue gas sample for evaluation in the ADA Technologies Field Resistivity Apparatus. The system is designed and fabricated to provide a 1 to 3 acfm flow of gas with the following constituents: 0-40 ppm SO_3; 0-4000 ppm SO_2; 0-500 ppm NO; 0-10% O_2; 0-12% H_2O; 0-15% CO_2; 0-85% N_2; and a particle loading of 0.5 to 8 gr/acf.

The conditioned flue gas exiting the chamber will flow to the resistivity precipitation chamber. The diameter of the point discharge electrode will be adjusted to simulate the electrical operating conditions of a full-scale ESP. Dust will be precipitated onto the lower grounded disc. An Insitec PCSV-E particle measurement instrument will be interfaced with the view ports of the chamber such that the sample volume lies between the high voltage discharge electrode and the collector disc. After a layer of dust 1/16th to 1/8th inch thick is precipitated, the dust feeder will be turned off. This will allow measurement of the particles being reentrained from the plate. The Insitec instrument measures particle size distribution, particle concentration, and particle velocity.

The flyash will be injected by the screw feeder and will mix with the conditioning agent in a conditioning chamber just upstream of the precipitation chamber. The flyash and the additive will be coprecipitated onto the lower disc. Once a sufficient layer has been collected, the injection of both the flyash and the conditioning agent will be eliminated. Tests will then be performed to quantify particle reentrainment as a function of velocity. The resistivity of the particles will also be measured for each conditioning agent. This will distinguish a change in reentrainment due to a modification of resistivity as opposed to a change from an increase in particle adhesion.

Although the data obtained from these screening tests cannot be used to directly predict the amount of improvement in an actual ESP, they do represent a measure of the actual reentrainment phenomenon that the conditioning agents are expected to influence. Therefore, the additives that perform well in the screening tests are most likely the ones that will provide the greatest improvement in an ESP.

Following these experiments, a preliminary cost analysis will be performed to determine if any of the candidate technologies should be eliminated at this point in the research program due to particularly excessive potential costs,.

Task 4. Bench-Scale Pilot Plant Testing

All of the conditioning agents that have successfully passed the laboratory screening will be evaluated in a bench-scale ESP operating on actual flue gas from a coal-fired utility boiler. The ADA bench-scale ESP is a portable device that can be operated in the field on a 100 acfm slipstream of flue gas. The bench-scale ESP unit has a single adjustable-width gas passage. The ESP unit is sized for a nominal 100 acfm sample of flue gas. The unit can be operated with 2 inch to 9 inch plate spacing at flow rates ranging from 60 to 135 acfm. It uses a rigid frame corona discharge electrode supported between plates that are 36 inches long and 12 inches high. The high voltage power supply is sized to allow operation up to 75,000 Volts, which results in a 6.6 kV/cm electric field strength with 9 inch spacing. The high voltage power supply can handle up to 1 mA of current which produces a current density of 180 $\mu A/cm^2$. Teflon stock is used for supports and baffles around the high voltage frame to minimize gas sneakage and prevent sparkover.

The site for the bench-scale tests of the candidate additives will be the experimental combustor maintained at Consolidation Coal Company's (CONSOL) Research and Development Labs in Library, PA. Combustor runs at the facility are typically a week in length, where the combustor is operated 24 hours a day. However, the typical workday for the research staff is 8 to 5; evening and overnight hours present an excellent opportunity to conduct tests with the bench-scale system that do not conflict with normal operations. There are several advantages to this location, including easy access to the flue gas stream, indoor setup of the bench-scale system, availability of utilities, operation in a research environment and a cooperative attitude of the CONSOL staff.

Part of this task will be to conduct a series of tests conducted on a slipstream from a utility boiler to obtain a correlation between data obtained using the Insitec instrument and reference particle sizing and mass loading measurement methods (i.e. impactors and Method 17). Tests will be performed at the inlet and outlet of the particulate control device to determine if the correlation between the measurement techniques changes with particle loading. Particle density will be measured using a helium pycnometer. This will be used when converting the data from the two techniques to a common form, either number distribution or mass distribution. The comparisons obtained in this sub-task will determine if the Insitec instrument is acceptable for both mass measurements and particle size distribution measurements at both the inlet and outlet of the ESP or if supplemental measurements will be required.

Task 5 Pilot Plant Testing

Based upon the bench-scale results, the most promising flue gas conditioning agents will be selected for further testing on the pilot ESP at the combustion research facilities of (CONSOL) in Library, Pennsylvania. This unit is different from the bench-scale ESP, which is to be set up and operated in the previous task at CONSOL on a slipstream from their research combustor.

The facility combustor can be set up to burn coal in either a wall-fired, tangential-fired, or cyclone-fired boiler configuration. Boiler configuration is important because the cyclone-fired boilers produce a significantly smaller flyash than the wall-fired and tangential-fired boilers. The coal to be used in the pilot-scale tests will be selected in consultation with the DOE TPO.

The two or three most promising additives will be tested in the pilot-scale ESP. The performance of the ESP with the various additives will be compared to the ESP collection efficiency measured under baseline operation with no conditioning. This test program will be broken down into two series of tests. In the first series, the performance of the ESP will be measured at baseline conditions and with each additive at only one value of SCA. The additive that provides the greatest performance improvement will under go further testing in the second series of tests. The second test will involve characterizing the performance of the ESP at baseline conditions and with additive injection over a range of operating conditions that will include two values of SCA and two gas velocities.

Following the baseline tests and each set of additive tests, the ESP will be thoroughly inspected. The purpose of the inspection will be to determine if the conditioning agents have lead to increased fouling of the corona wires or plates. Build up of dust in the hoppers will also be noted. The internals of the ESP will be photographed to document the conditions. Following the inspection, the collector plates will be air lanced so that the next conditioning agent will not be affected by material left on the plates by the previous test.

Task 6. Particle Surface Chemistry

In order to help understand the mechanisms by which the various additives led to an improved ESP performance, an analysis will be made of the particle surface chemistry of flyash samples obtained during the pilot-plant tests. Samples will be collected isokineticly on filters and then immediately stored in air tight containers. This will prevent further chemical reactions from occurring on the surface of the particles. The samples will then be shipped to the Chemical Analysis and Microstructure Laboratories at the Johns Manville Technical Center in Denver where they will be analyzed.

Task 7. ESP Modeling

Following the comprehensive data collection, performance of the pilot-scale ESP will be analyzed using the ESP computer model that has been developed by ADA. Since one of the objectives of this project is to research and develop methods to reduce particle reentrainment in coal-fired utility ESPs, it is important to have a model that accurately accounts for the factors contributing to particle reentrainment. The ADA ESP Model was developed to characterize the performance of ESPs operating downstream of dry flue gas desulfurization processes and is particularly suited for use in this application since the model incorporates a separate variable to account for the effects of particle reentrainment.

Comparisons of model predictions for flyash conditions have shown that the ADA ESP Model produces good agreement with existing ESP models. When conditions which result in increased particle reentrainment are considered, the ADA model produces better agreement with the measured conditions than do the other available models. The differences in the predictions are due to the different methods used to handle the non-ideal effects occurring in the ESP and the inclusion of particle space charge effects in the ADA model.

For each test condition the model will be run using the operating data measured during the test. The actual operating voltages and currents for each section of the ESP will be input into the model. The measured inlet mass loading and particle size distribution will also be input. The model calculates the collection efficiency of the ESP as a function of the user-specified particle size distribution. The model predictions will be compared to the measured values based upon the inlet and outlet mass loadings and particle size distributions. The non-ideal parameters for sneakage, gas flow distribution, and reentrainment will then be adjusted to provide a fit between the measured and predicted values.

Once the values for the non-ideal parameters are established, the data from the additives will be modeled to determine their impact on reentrainment and collection efficiency. This will establish new values for reentrainment that can be used to determine the amount of improvement that would result if the additives were used in full-scale ESPs.

Task 8. Waste Characterization

As a result of injecting flue gas conditioning agents into the flue gas, it is expected that the additive (or degradation products of the additive) will be found in the collected flyash. The presence of a conditioning additive in the collected ash can present a potential for environmental problems in the disposal of the flyash, or a potential for problems associated with ash use. Therefore, samples of the solid waste produced during flue gas conditioning will be evaluated to determine the impact of the additive on waste disposal. Experts in the analysis of solid wastes from Radian Corporation will determine the concentrations of water-soluble additives in collected flyash. The flyash will be subjected to a batch extraction using deionized water and the extract will be analyzed for the additive used, or for a characteristic associated with the additive.

Flyashes collected in the electrostatic precipitator with and without added conditioning agents will be subjected to the Toxicity Characteristic Leaching Procedure (TCLP). This test will be applied to determine if there is a difference in leachable metals present when ashes are collected with and without conditioning agents. The TCLP test is used to classify solids as characteristically hazardous if certain chemicals are found in concentrations in the leachate above specified levels. The TCLP extracts will be analyzed for the eight TCLP elements if ammonia or sulfur trioxide is the conditioning agent. The extracts will be analyzed for the eight TCLP metals and for 25 organics if an organic conditioning agent has been added.

Task 9. Economic Analysis

Finally, a detailed economic analysis of the successful and most promising candidate technologies will be performed to rank the technologies and compare their costs with one another and with alternative, more-conventional techniques to reduce fine particle emissions. Such conventional techniques include fabric filters and larger ESPs. Also, an economic analysis will help identify those techniques worthy and/or needful of additional, future research and/or suggest more economical means of accomplishing the same enhancements. The economic analysis will be performed for one specific unit size, for example, 250 MW. Also, a single appropriate precipitator size, for example, an SCA of 200 ft^2/kacfm, will be selected as a baseline for the analysis.

A total levelized cost-type analysis in terms of mils/kWh consistent with procedures established by EPRI will be used to compare the various technologies under consideration. Additionally, a present worth of revenue requirements (PWRR) type method may be used if it can better demonstrate the effects of remaining plant life on the economic tradeoffs of capital versus O&M costs.

Capital cost estimates for complete installed conditioning systems will be prepared based on input from vendors of the chemical conditioning systems and/or from information in the consultant's cost files. Similarly, operating and maintenance costs will be developed based on information from vendors of the various systems and chemicals and refined based on input and knowledge gained from this research program.

ACTIVITIES COMPLETED

TASK 1 MANAGEMENT PLAN

During this quarter a Management Plan was produced and submitted to DOE for approval. The Management Plan describes the activities, methods and evaluation criteria that would be used during the conduct of the project. This plan forms the basis for the direction of project tasks and overall fiscal and technical management of the project.

The Management Plan expanded upon the detail presented in the original proposal. A detailed test plan and quality assurance procedures were included in the Management Plan. A final part of this plan addressed developing Measures of Success. This is presented in the following paragraphs.

Measures of Success

This program will have two key decision points. The first will occur at the end of the bench-scale tests. After the data is analyzed, it will be necessary to rate the performance of the additives and to determine whether the improvements produced by the additives warrant additional testing at the pilot-scale. The second decision, similar to the first, will have to be made at the end of the pilot-scale tests. The experimental data obtained during Task 5 will be viewed in conjunction with the waste characterization, ESP modeling, and economic analysis to determine if the results show sufficient promise that DOE would consider additional funding to demonstrate the technology at a full-scale installation.

Although, these decisions might initially appear to be straight forward, a closer look at the technical issues involved reveals that it will be difficult to establish objective quantitative goals for the program that can be expressed in terms of a measurable improvement in performance.

The nature of the difficulty in establishing measures of success lies in the problem being addressed in this program. The objective of the program is to investigate conditioning agents that will produce improved collection efficiency of fine particles in an electrostatic precipitator. However, the additives will not have any impact on the primary particle collection mechanisms which are well understood theoretically and are easy to experimentally verify. Instead, the additives will produce their desired effect by modifying only the non-ideal effects, and these are not associated with either solid fundamental understanding or specific measurement technologies.

The "non-ideal effects" represent, by definition, the mechanisms that cannot be explained by ESP theory but are a very real part of the performance of a full-scale ESP. The non-ideal effects fit into several categories which include:

- o Sneakage
- o Non-uniform distribution of gas flow
- o Non-rapping reentrainment
- o Rapping reentrainment
- o Hopper reentrainment

Since the first two non-ideal effects are due to the gas flow characteristics which result from the physical configuration of the ESP, the additives cannot be expected to affect these processes. However, an additive that increases the cohesive characteristics of the particles could decrease the magnitude of all forms of reentrainment.

The magnitude of rapping reentrainment can be measured by comparing emissions with and without rapping. However, the other non-ideal effects are continuous processes and are therefore difficult to quantitatively characterize. By measuring emissions at the outlet of an ESP, it is not possible to determine whether the particles are penetrating the ESP because they have not been collected or because they have either been reentrained or have by-passed the active sections of the ESP. About the only possible means to determine the cause of emissions is to compare actual performance with theoretical performance and then attribute the difference to non-ideal effects. However, this technique can only be effective if the non-ideal effects result in a significant contribution to the total emissions.

The role that the non-ideal effects play in ESP performance vary from unit to unit, but in general, the greater the collection efficiency, the greater the impact of the non-ideal effects. For a high efficiency ESP (i.e. 99.9% collection efficiency), non-ideal effects can be the root cause of the majority of emissions. Therefore, a process that reduces reentrainment will result in a large reduction in emissions. However, for a smaller and subsequently less efficient ESP, a similar reduction in the magnitude of reentrainment will have a lesser impact on overall emissions. For these reasons, any definition of a measure of success will have to take into consideration the size and performance of the ESP.

Another difficulty in defining a measure of success results from interpreting data obtained from reduced-scale precipitators. Although the additives have the potential for reducing all forms of reentrainment, rapping reentrainment and hopper boil-up cannot be adequately simulated in the bench-scale ESP. The primary effect of the additives that will be characterized in these tests will be non-rapping reentrainment. In the pilot-scale tests, rapping and hopper reentrainment will begin to become a factor, but because the plate height in the pilot unit is much smaller than full-scale plates, the magnitude of the effects of these forms of reentrainment will not be as significant. Therefore, a small improvement produced in the bench-scale and pilot-scale tests should represent the potential for a much greater amount of improvement when the additive is used in a full-scale unit.

Another major uncertainty is due to the fact that the ultimate target for this technology is not adequately defined at this point in time. The additives will be used as a retrofit technology on existing ESPs. The need for improving the performance of an existing ESP will be driven by either local regulations requiring a decrease in emissions or new regulations related to air toxics imposed at the national level. Since these specific standards will not be established until some time in the next couple of years, assumptions must be made about the specific targets for this program.

The final uncertainty is due to the site specific nature of the benefits of this technology. The relative reduction in outlet emissions produced by the additives increases with ESP efficiency. However, the lower the baseline efficiency, the greater the improvements have to be to meet a fixed standard. Therefore, there will be an optimum size ESP for this technology which will depend on the new regulations. If an ESP is very small, there may not be sufficient improvement available with the additives to reach the emission limits. On the other hand, very large ESPs may not need any improvement at all.

The age of the boiler might also play an important role in determining the cost-effectiveness of the additives. If there are many years of life left on a boiler, there might be justification of a large capital expenditure for a baghouse or new ESP. However, for a very old boiler with only a fews years of service remaining, the low-capital costs associated with chemical conditioning might appear relatively attractive.

In conclusion, defining a measure of success must take into account all of the factors mentioned above. In order to do this it will be necessary to use the computer ESP model to extrapolate the data from the small-scale systems to the various full-scale units. This analysis must then be incorporated into the economic analysis to define the potential for success. Therefore, the measures of success must be expressed in terms of providing improved collection efficiency in a cost-effective manner. The following criteria are suggested for measures of success for the bench-scale and pilot-scale tests.

- The bench-scale tests are very important because they represent the first test site where the additives must function in the presence of actual flue gas. However, the small size of the test unit eliminates many of the means by which the additives could provide an improvement in performance. Therefore, a small improvement in performance in the bench-scale tests could lead to a much greater improvement when applied to a larger-scale unit. Success for an additive will be achieved if a statistically significant improvement in collection efficiency occurs. Since multiple Method 17 measurements will be made for the baseline (no additive) tests and for each additive condition, there will be sufficient data to perform a Student's T test to determine if the change in performance is statistically significant. If many additives meet this criterion, then the additives will be rated according to the magnitude of improvement.

- The pilot-scale tests will provide an opportunity to measure more significant levels of performance improvement. The pilot data will be used in conjunction with the ESP computer model to predict the amount of improvement that could be achieved in a full-scale ESP. The economic analysis will be used to determine the costs associated with using the additives. The measure of success will be based on the additive providing a cost-effective technology to achieve a 50% reduction in emissions from a full-scale ESP.

TASK 2. SELECTION OF ADDITIVES

Activities in Task 2 were initiated during this quarter. This task involves identifying additives that could be used as flue gas conditioning agents for ESPs. There are several chemicals that are currently being marketed for this specific purpose, including bulk injection of NH_3 and SO_3, and products from Nalco Fuel Tech and Calgon. Liquid ash cohesion modifiers coprecipitate with fine flyash particles, which results in increased flyash collection. Other additives include liquid organic/inorganic formulations which control particulate emissions and opacity of stack gases from either hot-side or cold-side ESPs. However, if this experimental program was limited to only those products currently on the market as ESP elixirs, an excellent opportunity to advance the state-of-the-art would be missed.

In order to provide a more thorough coverage of potential conditioning agents, the search will include products that were not specifically designed for ESPs. There are other classes of materials where potential candidates for flue gas conditioning might be found. Several companies sell chemical products for control of fugitive emissions from coal and mineral storage piles, from conveyor transfer points, and from unpaved roads. These products cover a range of chemicals and include surfactants, adhesives, polymer resins, foams, and emulsions. Although the conditions are quite dissimilar from an ESP, the ultimate purpose of the additive is identical: to increase adhesive/cohesive characteristics of the dust to prevent reentrainment of particles. These products will be reviewed to determine which ones are likely to survive and function in a flue gas at 300 ^oF. Other products will be identified from additives used in various powder coating technologies.

Conventional ESP Additives

There are two additives that are in current use on a commercial basis to enhance the performance of ESPs. These are NH_3 and SO_3, which are used independently and together to improve the collection efficiency. The improvement is believed to be due mainly to changes in the electrical properties of the flyash, although there may be some increase in the adhesion of the particles from the agents.

The injection of NH_3 and SO_3 provides several physical and chemical effects that affect ESP performance:

- o It can form solid ammonium sulfate, $(NH_4)_2SO_4$, particles which are very small and can increase the particulate space charge in an ESP and alter the electrical operating conditions.
- o It can form liquid ammonium bisulfate, NH_4HSO_4 which condenses on the particles and increases their surface adhesion.
- o It can modify the particle resistivity.

Whether ammonia sulfate or bisulfate is formed depends upon the flue gas characteristics and especially on the ratio of NH_3 to SO_3. Therefore, when testing with NH_3/SO_3 conditioning, the ratio of the two chemicals becomes an important parameter. However, in cases where the SO_3 is generated in the combustion process, as opposed to being injected, it becomes very difficult to control the ratio of the gases.

For conditioning with NH_3, there are two ways to inject the ammonia into the flue gas: vaporize anhydrous ammonia and inject it as a gas or inject a liquid chemical such as ammonium nitrate which will decompose in the flue gas to form NH_3. Since the end product of the conditioning in both cases is to supply NH_3 for reacting with SO_3, these two technologies will not be tested separately in this program. The differences between these two approaches only becomes important when comparing capital and operating costs.

New Candidate Additives

In addition to the commercially-available products for improved ESP particle collection efficiency, a number of other products will be investigated that are not specifically made for ESPs. These candidate materials could be added to the flue gas to serve as an adhesive or wetting agent which would bind the fine particles together and thereby improve their collection in the ESP.

Surfactants improve water's ability to wet surfaces by lowering its high surface tension. Less than 100 parts per million of surfactant is needed to transform water's high energy surface to a low energy surface, thereby increasing the ability of water to wet heterogeneous materials such as flyash. When mixed with water in sprays, surfactants serve to decrease droplet size, resulting in more and finer droplets which collide more frequently with fine particles. One thousand to three thousand parts per million of surfactant is required to produce this effect.

One type of surfactant is the mono- or di-phosphate ester. These liquid compounds exhibit emulsifying, lubricating, antistatic, detergent and corrosion-inhibiting properties. The phosphate ester surfactants are free acids which are converted to the salt of an alkali metal, amine, or ammonia by mixing with the respective base.

Another type of surfactant is the 1-hydroxyethyl-2-alkylimidazoline. This surfactant has a pH range of 10.5 to 12. The amber liquid is oil-soluble and water dispersible, contains no solvents, and is classified as a cationic surface-active agent. These organic monobasic cyclic tertiary amines exhibit moderately strong alkaline properties. They are either neutralized with common acids to give amine salts, or combined with alkyl halides and sulfates to form quaternary ammonium compounds. This surfactant is strongly adsorbed on negatively-charged surfaces, such as siliceous materials. The salts are prepared as 20% aqueous solutions during neutralization.

Two additional types of surfactants, one an organic-based liquid containing ethylene glycol and diethylene glycol and the other containing ethoxylated nonylphenol, are used primarily for dust control. Both surfactants are diluted with water and spray-applied to material at a rate of one-half to two gallons of solution per ton of material.

Another candidate surfactant is a concentrated emulsion of natural petroleum oils and resins (60% resins, 40% wetting solution). The resins are the film-forming, dust-binding portions, while the wetting solution (which is miscible with water) keeps the petroleum resin dispersed in finely divided particles. This product coats dust particles and forms cohesive membranes that bond adjacent particles. Other types of surfactants contain 2-butoxyethanol, dodecylphenoxypoly(ethyleneoxy)ethanol, and the ammonium salt of ethyoxylated and sulfated decyl and octyl alcohols.

In addition to surfactants, adhesive materials may effectively bind fine particles together when diluted with water and sprayed into the flue gas. One adhesive compound which will be investigated for this application is polyvinyl alcohol.

Polyvinyl alcohols are manufactured for a wide range of applications, although they are not generally used for dust suppression. Properties of the polyvinyl alcohols which would make them good dust suppressors include adhesion and bonding. Polyvinyl alcohols vary in their degree of hydrolysis and viscosity. The super-hydrolyzed grades are recommended for maximum water and humidity resistance. Partially hydrolyzed grades have better adhesion to hydrophobic surfaces. A fully-hydrolyzed, medium viscosity polyvinyl alcohol is recommended for flyash in a high-humidity environment, although a lower viscosity alcohol is more appropriate for spray injection.

PLANS FOR NEXT QUARTER

All plans for the next quarter are contingent upon obtaining approval of the Environmental Assessment (EA) for the project so that the scheduled activities can proceed as planned. If the EA is not approved, then the only activities will involve the identification of additives for testing.

When the EA is approved, work will begin in both Task 3 and Task 4. In Task 3, the experimental equipment required for the laboratory testing will be designed and assembled. In Task 4, the auxiliary equipment to operate the bench-scale ESP will be designed. In addition, preparation will begin to perform the evaluation of the Insitec Instrument.

END

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