Energy & Environmental Research Center

IMPACT OF SCR CATALYST ON MERCURY OXIDATION IN LIGNITE-FIRED COMBUSTION SYSTEMS

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ABSTRACT

A major challenge facing North Dakota lignite-fired power plants is the control of mercury emissions. The mercury species in combustion flue gases produced from North Dakota lignite plants is primarily elemental and much more difficult to control than oxidized mercury forms. The goal of this project is to determine the effect of new and aged catalyst on the oxidation of mercury at full-scale power plants. The proposed project will conduct testing to determine the Hg oxidation across selective catalytic reduction (SCR) catalyst occurring in the short-term (6 months). The testing will be conducted on lignite coal at the Coyote Station. The scope of work involves utilizing the existing project on catalyst blinding by adding mercury sampling and analysis to the testing at a lignite-fired boiler (Coyote Station).

The results of this work will provide a better understanding of the behavior of mercury over time across existing SCR catalysts in lignite coal-fired boilers. This will provide insight into developing improvements in mercury capture within the combustion system using SCR catalyst technology to reduce NO_x emissions, thereby reducing the mercury burden on the environment from fossil energy production.

Total project cost is $100,000. The proposed utility sponsors include Basin Electric Power Cooperative, Great River Energy, Minnkota Power Cooperative Inc., Montana–Dakota Utilities Co., and Otter Tail Power Company. The amount requested from each utility sponsor is $6000, for a total amount requested from utility sponsors of $30,000. The request from the North Dakota Industrial Commission (NDIC) is $30,000. The amount requested from the Energy & Environmental Research Center–U.S. Department of Energy Jointly Sponsored Research Program will be $40,000.

IMPACT OF SCR ON MERCURY OXIDATION IN LIGNITE-FIRED COMBUSTION SYSTEMS

PROJECT SUMMARY

There is speculation that the installation of selective catalytic reduction (SCR) for reduction of NO_x between now and 2010 could significantly increase oxidation and improve removal of mercury in U.S. coal-fired plants. Information collection request (ICR) emission tests performed at two plants with SCRs did not provide conclusive answers because of the masking effects of other variables. European investigators have reported complete oxidation of elemental mercury (Hg^0) to $HgCl_2$ on the surface of SCR catalyst in the presence of HCl in laboratory tests and a smaller decrease in the elemental fraction of mercury from 40% to 60% to 2%–12% in full-scale power plants, where the effect of the SCR catalyst was believed to be influenced by reducing gases and fly ash. Recent pilot-scale tests on the effect of SCR, performed by the Energy & Environmental Research Center (EERC), showed a substantial increase in the fraction of particulate-bound mercury across the SCR when two high-chlorine eastern bituminous coals were burned, but essentially no effect on speciation when a low-chlorine Powder River Basin (PRB) subbituminous coal was burned. Changes in mercury speciation are coal-specific and appear to be related to the chloride, sulfur, and calcium content of the coal, as well as operating temperature and ammonia (NH_3) concentrations in the flue gas. Tests at full-scale power plants with SCR are currently being conducted. Preliminary results show the oxidation of mercury across the SCR occurs for some coals but not others. The oxidation appears to depend upon the coal type and gas residence time in the SCR catalyst. In addition, the degree of oxidation also appears to be dependent on the length of time a catalyst is in operation. Very little data are available on the impact of age on the potential of an SCR catalyst to oxidize mercury. This

project aims to provide both data on the ability of new catalyst to promote oxidation as well as data on how hours of operation impact the ability of a catalyst to oxidize Hg^0.

Currently, the EERC is conducting a project entitled "Evaluation of Potential SCR Catalyst Blinding During Coal Combustion." The primary goal is to determine the potential of low-rank coal ash to cause blinding or masking of SCR catalysts. Two slipstream reactors were designed and constructed. The reactors are designed for remote computer-controlled operation and data collection. The SCR reactor is approximately a 7.5-inch-square by 8-foot-long steel housing that consists of two sections: one flow straightener and a catalyst test section. One reactor was initially installed at Dynegy's Baldwin Station in Illinois and operated for nearly 1500 hours; after 6 months of operation, the reactor has been removed, is currently being serviced at the EERC, and will be moved to Otter Tail Power Company's Coyote Station in North Dakota in March of 2003.

PROJECT DESCRIPTION

Goals and Objectives

The primary goal of this project is to determine the effect of new and aged catalyst on the oxidation of mercury at full-scale power plants. In order to meet this goal, testing will be conducted to determine the Hg oxidation across SCR catalyst occurring in the short term (6 months). The testing will be conducted on lignite coal at the Coyote Station. The scope of work takes advantage of the existing project on catalyst blinding by adding mercury sampling and analysis to the testing at a lignite-fired boiler (Coyote Station).

Workplan

Task 1 – Characterization of Hg Transformations Across SCR Catalysts for a Lignite Coal-Fired Boiler

Testing for 6 months will be conducted at a lignite-fired combustor in conjunction with the existing project to characterize the blinding of catalysts. Ontario Hydro (OH) sampling will be performed in triplicate on a 2-month interval, taking mercury measurements before and after the SCR catalyst to determine the degree of oxidation of mercury across the catalyst. In addition, continuous mercury monitors (CMMs) will be used for a short duration. The results of the CMMs will be compared to the OH samples. The current reactor is fully automated and equipped with the necessary ports for mercury sampling. The effect of temperature and gas velocity will also be determined. Samples of coals fired during the testing will be collected and analyzed for Hg content as well as proximate, ultimate, and ash composition. This effort will be conducted over the first 6 months of the project, concurrent with the existing project.

Task 2 – Project Management, Data Analysis, and Reporting

The project participants will include a consortium of utilities and coal mining companies. The data will be analyzed in terms of reduction of mercury oxidation over time. In addition, the effects of temperature and gas flow rates will be reported on their ability to oxidize mercury. Quarterly reports and a final report will include all data, and interpretations will be prepared.

STANDARDS OF SUCCESS

Quality Assurance/Quality Control (QA/QC)

To ascertain data quality obtained during the sampling program, the following procedures are to be used:

- Process operating data will be examined to ensure that sampling took place during steady, representative plant operation.
- Sampling and analytical analysis protocols will be reviewed to ascertain how the data compared with other data generated using standard protocols.
- The type and quantity of QA samples will be reviewed to qualitatively determine the confidence that can be placed in the results.
- The QA/QC data results will then be compared with data quality indicators to qualitatively determine the validity of the data in terms of variability and accuracy.

These procedures are part of an overall QA/QC program in place at the EERC and are designed to maintain overall data integrity.

Process Data Evaluation

Plant operating data will be examined to ensure that process operation was stable and representative during the sampling periods. Data scatter or significant trends in relevant process variables can indicate periods of nonrepresentative unit operation. Data scatter is useful for identifying periods of operational difficulty; data trends indicate periods when steady-state operation has not been achieved.

Flue gas data for criteria pollutants (SO_2, NO_x, and opacity) are collected by the plant using state-approved continuous emission monitors (CEMs). These units are calibrated as required by the state as part of its State Implementation Plan (SIP call). Temperatures are obtained using standard thermocouples and other flue gas information. Gas flow rates, stack CO_2 and CO concentrations, and SCR inlet and outlet NO_x concentrations are obtained using state-approved techniques. NH_3 injection rate is determined using gravimetric analysis.

Stack-Sampling Quality Control Evaluation

Sampling precision can be estimated by comparing the results for various parameters of the replicate samples, notably, velocity, moisture content, and gas composition in the stack. Sampling accuracy is usually inferred from the calibration and proper operation of the equipment and from historical validation of the methods. Field blanks and spikes are used to determine any biases that may be caused by contamination or operator errors. Blanks and spikes are included for all tests.

Sampling comparability depends on the representativeness of the samples and on the use of standard methods consistently applied. All methods that will be used are standard American Society for Testing and Materials or U.S. Environmental Protection Agency sampling methods. Sampling completeness is mainly a function of providing the requisite number of samples to the analytical laboratory. In most cases, these are triplicate samples.

The isokinetic sampling rate is a measure of the operational performance of sampling for particulate matter and can be used as an indicator of precision, with consequences for representativeness. The acceptance criteria for isokinetic variation is 10%.

Evaluation of Measurement Data Quality

An evaluation of the measurement data quality is based on QC data obtained during sampling and analysis. Generally, the type of QC information obtained pertains to measurement precision, accuracy, and blank effects, determined by collecting various types of replicate, spiked, and blank samples. The specific characteristics evaluated depend on the type of QC checks performed. For example, blanks may be prepared at different stages in the sampling and analysis process to isolate the source of a blank effect. Similarly, replicate samples may be generated at different stages to isolate and measure the sources of variability. Table 1 summarizes the QA/QC measures used and the characteristic information obtained.

As shown in Table 1, different QC checks provide different types of information, particularly pertaining to the sources of inaccuracy, imprecision, and blank effects. In general, measurement precision and accuracy are typically estimated from QC indicators that cover as much of the total sampling and analytical process as feasible. Precision and accuracy estimates are based primarily on the actual sample matrix.

Table 1. Elements of the QA/QC Plan

QC Activity	Characteristic Measured
Precision	
Replicate Samples Collected over Time under the Same Conditions	Total variability, including process or temporal, sampling, and analytical but not bias.
Duplicate Analyses of a Single Sample	Analytical variability at the actual sample concentrations.
Matrix-Spiked Duplicates	Sampling plus analytical variability at an established concentration.
Laboratory Control Sample (LCS) Duplicates	Analytical variability in the absence of sample matrix effects.
Accuracy (including precision and bias)	
Matrix-Spiked Samples (field spikes)	Analyte recovery in the sample matrix, indicating possible matrix interferences and other effects. In a single sample, includes both random error (imprecision) and systematic error (bias).
LCS	Analyte recovery in the absence of actual sample matrix effects. Used as an indicator of analytical control.
Blank Effects	
Field Blank	Total sampling plus analytical blank effect, including sampling equipment and reagents, sample transport and storage, and analytical reagents and equipment.
Method Blank	Blank effects inherent in analytical method, including reagents and equipment.
Reagent Blank	Blank effects from reagents used.

Data quality objectives are used by the laboratory, not as validation criteria, but as empirical estimates of the precision and accuracy that would be expected from existing reference measurement methods and that would be considered acceptable. In some cases, precision and accuracy estimates are not necessarily derived from analyses of the same types of samples being investigated. Although analytical precision and accuracy are relatively easy to control and quantify, sampling precision and accuracy are unique to each site and each sample matrix. Data that do not meet these objectives are by no means necessarily unacceptable. Rather, the intent is to document the precision and accuracy actually obtained, and the objectives serve as benchmarks for comparison. The effects of not meeting the objectives should be considered in light of the intended use of the data.

Specific QC procedures to be used to measure mercury in the flue gas are described below.

Instrument Setup and Calibration

The instrument used in the field for mercury determination is a Leeman Labs PS200 cold-vapor atomic absorber. To measure mercury, the instrument is set up for absorption at 253.7 nm, with a carrier gas of nitrogen and 10% $^{w}/_{v}$ stannous chloride in 10% $^{v}/_{v}$ HCl as the reductant. Each day, the drying tube and acetate trap are replaced and the tubing checked. The rinse container is cleaned and filled with fresh solution of 10% $^{v}/_{v}$ HCl. After the pump and lamp are turned on and warmed up for 45 minutes, the aperture is set to manufacturer specifications. A four-point calibration curve is then completed using matrix-matched standards. The detector response for a given standard is logged and compared to specifications to ensure the instrument has been properly set up. A QC standard of a known analyte concentration is analyzed immediately after the instrument is standardized in order to verify the calibration. This QC standard is prepared from a different stock than the calibration standards. It is required that the values obtained read within 5% of the true value before the instrument is used. After the initial QC standardizations are completed, standards are run every five samples to check the slope of the calibration curve. All samples are run in duplicate, and one in every ten samples is spiked to verify analyte recovery. A QC chart is maintained at the EERC to monitor the long-term precision of the instrument.

Presampling Preparation

All data sheets, volumetric flasks, and petri dishes used for sample recovery are marked with preprinted labels. The liquid samples are recovered into premarked volumetric flasks, logged, and then analyzed on-site. The baghouse outlet filter samples are placed in premarked petri dishes and taken back to the EERC, where they are analyzed using mixed-acid digestion techniques. The labels will contain identifying data: date, time, run number, sample port location, and the name of the sampler.

Glassware and Plasticware Cleaning and Storage

All glass volumetric flasks and transfer pipets used in the preparation of analytical reagents and calibration standards will be designated Class A to meet federal specifications. Prior to being used for the sampling, all glassware will be washed with hot, soapy water, then rinsed with deionized water three times, soaked in 10% $^{v}/_{v}$ nitric acid for a minimum of 4 hours, rinsed an additional three times with deionized water, and dried. The glassware will then be stored in closed containers until it is used at the plant.

Analytical Reagents

All acids to be used for the analysis of mercury will be trace metal-grade. Other chemicals to be used in the preparation of analytical reagents will be analytical reagent-grade. The calibration standards used for instrument calibration and the QC standards used for calibration verification will be purchased commercially, certified to be accurate within 0.5%,and be traceable to National Institute of Standards and Technology standard reference materials.

Blanks

As part of the QA/QC procedures, field blanks will be completed. A field blank is defined as a complete impinger train, including all glassware and solutions, taken out to the field during sampling and exposed to ambient conditions. These sample trains are then taken apart and the solutions recovered and analyzed in the same manner as those sample trains used for sampling activities. If the field blank shows contamination above instrument background, steps must be taken to eliminate or reduce the contamination to below background levels. It is planned that one field blank will be associated with each sample location. For this project, sampling will occur upstream and downstream of the SCR catalyst and will be conducted at the beginning of the project and at 2-month intervals during the course of the project, resulting in a minimum of four field blanks for the project.

All acids, chemical reagents, and deionized water used for mercury determination will be analyzed for background levels of mercury. Each time a new batch of reagents is prepared, an aliquot will be immediately taken and analyzed for mercury (reagent blank).

Spiked Samples

In order to ensure that adequate levels of accuracy are maintained, spiked samples also will be submitted for analysis. These samples will be made up independently of the chemist doing the analyses. The spikes are required to be within 15% of the true value. If the value is not within the specified limits, then the instrument is to be recalibrated and the samples reanalyzed. The spiking solutions will be made from stock separate from the calibration standard. The primary method of spiking involves the use of field spikes. These are similar to field blanks in that the entire sampling train is assembled as if it will be used for flue measurements and then is spiked with a known amount of mercury. The train is taken to the sampling location but not used. The field spiked train is then recovered using the standard procedures, and analysis is completed as if it were an actual train used for measurement purposes. In addition to field spikes, laboratory control samples are done. In this case, actual samples that have been analyzed are spiked and then reanalyzed to determine spike recovery.

BACKGROUND

Mercury Speciation and SCR Catalysts

Mercury speciation in flue gases produced from coal-fired power plants can be classified into three main forms: Hg^0, oxidized mercury (Hg^{2+}), and particle-bound mercury (Hg_p). Total mercury levels in coal combustion flue gas typically range from 3 to 15 $\mu g/m^3$; however, the proportions of Hg^0, Hg^{2+}, and Hg_p depend on coal composition and, to a minor extent, combustion conditions (1).

During combustion, mercury in the coal is transformed to Hg^0. However, depending on the coal type, a significant fraction of the Hg^0 can be oxidized to Hg^+ as well as become associated with the fly ash particles in the postcombustion environment of a coal-fired boiler. The oxidized and particulate forms of mercury are more effectively captured in conventional pollution control systems, such as wet scrubbers, fabric filters, and electrostatic precipitators (2–6).

In addition to mercury, NO_x emissions are an environmental concern primarily because they are associated with increased acidic precipitation, as well as fine-particle and ozone formation. Depending on the size and type of boiler, the 1990 Clean Air Act Amendments require specific reductions in NO_x emissions from coal-fired electric utilities. The most common NO_x reduction strategy is the installation of low-NO_x burners. These burners have the capability of reducing NO_x emissions by 40%–60%. However, with possible establishment of $PM_{2.5}$, regional haze, and ozone regulations and NO_x SIPs, there is increased incentive to reduce NO_x emissions to a level below what can be achieved using low-NO_x burners. SCR technology, which can reduce NO_x emissions by >90%, is, therefore, becoming more attractive, particularly because catalyst costs continue to decrease and the knowledge base for using SCR reactors is expanding. Within the next 5 years, 80 to 90 U.S. utilities are planning to install SCR units (7).

SCR systems are used to lower NO_x emissions by reducing NO_x to N_2 and H_2O by using NH_3 as the reductant. SCR systems utilize metal oxide catalysts such as titanium dioxide (TiO_2)-supported vanadium oxide (V_2O_5) and are operated at about 650°–750°F. Laboratory-scale testing indicates that metal oxides, including V_2O_5 and TiO_2, promote the conversion of Hg^0 to Hg^{2+} and/or Hg_p in relatively simple flue gas mixtures (8). In addition, mercury speciation measurements at European coal-fired boilers equipped with SCR reactors have indicated that SCR catalysts promote the formation of Hg^{2+} (9, 10). Therefore, it has been hypothesized that the use of an SCR may improve the mercury control efficiency of existing air pollution control devices by promoting Hg^{2+} and/or Hg_p formation.

Based on the aforementioned evidence, there is speculation that the installation of SCR for reduction of NO_x could significantly increase oxidation and improve removal of mercury in coal-fired plants. ICR emissions tests performed at two plants with SCRs did not provide conclusive answers because of the masking effects of other variables. European investigators have reported complete oxidation of Hg^0 to $HgCl_2$ on the surface of SCR catalyst in the presence of HCl in laboratory tests and a smaller decrease in the elemental fraction of mercury from 40%–60% to 2%–12% in full-scale power plants, where the effect of the SCR catalyst was believed to be influenced by reducing gases and fly ash. Pilot-scale tests performed by the EERC on the effect of SCR showed a substantial increase in the fraction of particulate-bound mercury across the SCR when two high-chlorine eastern bituminous coals were burned, but essentially no effect on speciation when a low-chlorine PRB subbituminous coal was burned. Changes in mercury speciation are coal-specific and appear to be related to the chloride, sulfur, and calcium content of the coal, as well as operating temperature and NH_3 concentrations in the flue gas. Tests at full-scale power plants with SCR are currently being conducted. Preliminary results show the oxidation of mercury across the SCR occurs for some coals and not others. The oxidation appears to depend upon the coal type and gas residence time in the SCR catalyst. In addition, the degree of oxidation also appears to be dependent on the length of time a catalyst is in operation. Very little data are available on the impact of prolonged exposure of an SCR catalyst to flue gas and ash constituents on the potential to oxidize mercury.

Ash-related impacts on SCR catalyst performance depend upon the composition of the coal, the type of firing systems, flue gas temperature, and catalyst design (11–14). The problems currently being experienced on SCR catalysts include the following:

- Formation of sulfate- and phosphate-based blinding materials on the surface of catalysts.
- Carrying of deposit fragments, or popcorn ash, from other parts of the boiler and depositing on top of the SCR catalysts.

Licata and others (11) conducted tests on a South African and German Ruhr coal and found that the German Ruhr coal significantly increased the pressure drop across the SCR catalysts because of the accumulation of ash. They found that the German coal produced a highly adhesive ash consisting of alkali (K and Na) sulfates. In addition, they reported that the alkali elements are in a water-soluble form and highly mobile and will migrate throughout the catalyst material, reducing active sites. The water-soluble form is typical of organically associated alkali elements in coals. The German Ruhr Valley coal has about 9.5% ash and 0.9% S on an as-received basis, and the ash consists mainly of Si (38.9%), Al (23.2%), Fe (11.6%), and Ca (9.7%), with lower levels of K (1.85%) and Na (0.85%) (12). Cichanovicz and Muzio (13) summarized the experience in Japan and Germany and indicated that the alkali elements (K and Na) reduced the acidity of the catalyst sites for total alkali content (K + Na + Ca + Mg) of 8%–15% of the ash in European power plants. They also found that alkaline-earth elements such as calcium react with SO_3 on the catalyst, resulting in plugging of pores and a decrease in the ability of NH_3 to bond to catalyst sites. The levels of calcium in the coals that caused blinding ranged from 3% to 5% of the ash.

The mechanisms for this type of low-temperature deposition have been examined and modeled in detail at the EERC in work termed Project Sodium and Project Calcium in the early 1990s; however, the focus of those projects was specific to primary superheater and economizer regions of boilers and not SCR systems (15, 16). Deposit buildup of this type can effectively blind or mask the catalyst, diminishing its reactivity for converting NO_2 to N_2 and water and potentially creating increased NH_3 slip (11). Arsenic and phosphates, which are not uncommon in low-rank coals, may also play a role in catalyst degeneration. Arsenic is a known catalyst poison (11) in applications such as catalytic oxidation for pollution control. Phosphates can occur in low-temperature ash deposits to create blinding effects, and they also occur with arsenic and can cause catalyst poisoning (12).

SCR Catalyst Blind Project and Equipment

The primary goal of the SCR Catalyst Blinding project is to determine the potential of low-rank coal ash to cause blinding or masking of SCR catalysts. Specific objectives include

1) identifying candidate coals and blends for testing under bench-scale conditions; 2) conducting bench-scale testing to screen coals and identify key conditions for testing at the full scale; 3) designing and constructing an SCR slipstream test chamber for sampling at full-scale facilities; 4) conducting testing at full-scale facilities; 5) identifying SCR blinding mechanisms, rates, and cleaning methods; and 6) interpreting data, preparing a report, and attending sponsor meetings to present information and recommendations.

Two reactor systems have been completed. A schematic diagram of the reactors is shown in Figure 1. The first reactor has completed over 6 months of continuous operation at Dynegy's Baldwin Station and will be moved to Coyote Station in North Dakota in January. The second reactor is installed at Alliant Energy's Columbia Station and has begun operation.

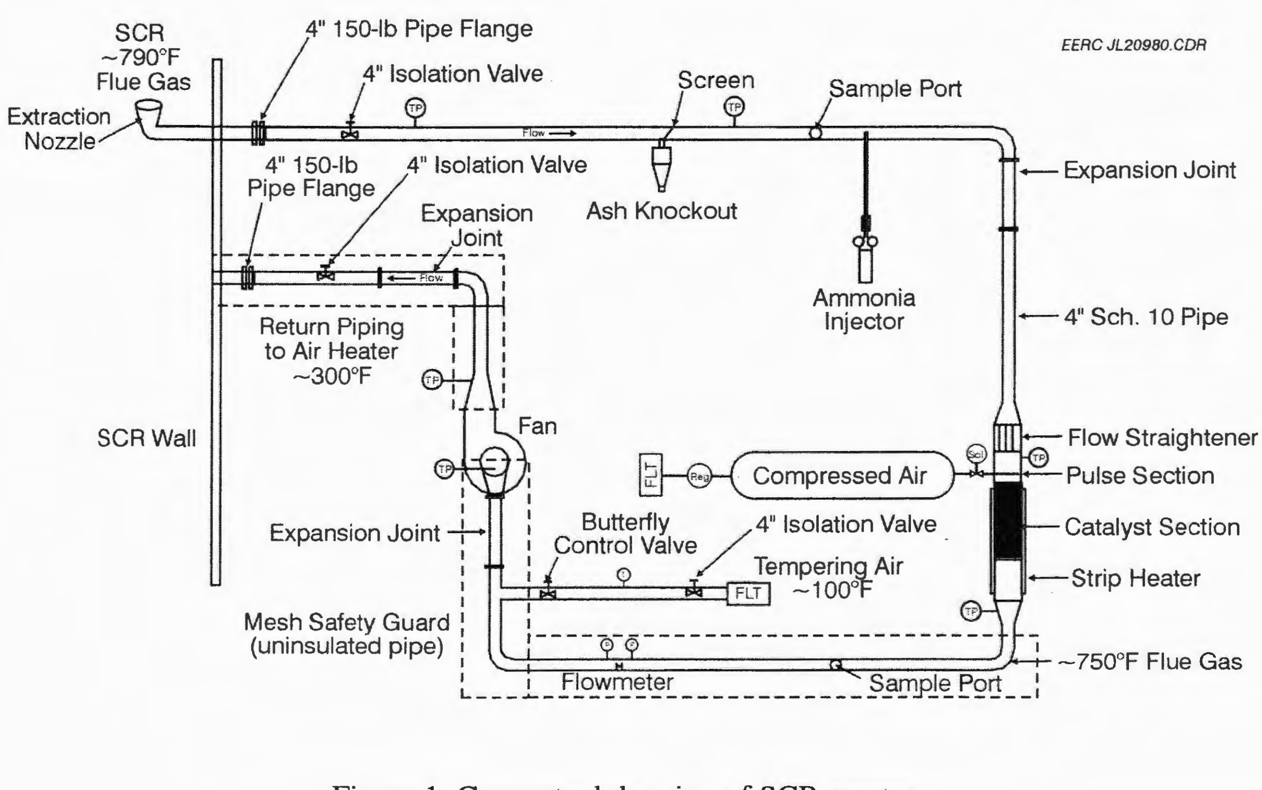


Figure 1. Conceptual drawing of SCR reactor.

A purge section is installed ahead of the catalyst section to remove accumulated dust. The catalyst section is equipped with strip heaters and insulation to maintain a constant operating temperature. Thermocouple and pressure taps will be located in the purge sections for measurements before and after each section.

The reactor temperatures, sootblowing cycles, and gas velocities are all controlled through a computer system that can be remotely accessed via a phone line. The computer system also continuously logs data that include all temperatures, pressure drops, sootblowing cycles, and fan operating parameters. This information is downloaded for analysis and interpretation on a daily basis.

QUALIFICATIONS

The EERC of the University of North Dakota is one of the world's major energy and environmental research organizations. Since its founding in 1949, the EERC has conducted research, testing, and evaluation of fuels, combustion, and gasification technologies; emissions control technologies; ash use and disposal; analytical methods; groundwater; waste-to-energy systems; and advanced environmental control systems. Today's energy and environmental research needs typically require the expertise of a total-systems team that can focus on technical details while retaining a broad perspective. The EERC team has more than four decades of basic and applied research experience producing energy from all ranks of coal, with particular emphasis on low-rank coals. As a result, the EERC has become the world's leading low-rank coal research center. EERC research programs are designed to embrace all aspects of energy-from-coal technologies from cradle to grave, beginning with fundamental resource characterization and ending with waste utilization or disposal in mine land reclamation settings.

The future of North Dakota energy production depends upon developing connections between energy and environment that will allow the extraction of sufficient energy and other resources from our environment in a manner that does not jeopardize its integrity and stability. The EERC fulfills a valuable part of this future challenge by developing SCR research efforts that will effectively develop partnerships between industry, researchers, and state agencies.

With respect to NO_x emissions, the EERC has been performing studies in low-NO_x burner technologies, catalytic effects on NO_x conversion, fly ash quality from low-NO_x burner or overfired air technology installation, and fuel impacts on NO_x emissions for over 25 years. Several successful projects, including over 20 field tests, have been conducted at various utilities throughout the United States to perform flue gas sampling, air toxic emission monitoring, fly ash collection, and fouling and slagging deposit sampling. Several of those field tests involved working with plant slipstreams or direct sampling using custom-designed and -manufactured sampling equipment.

The EERC has been a leader in mercury research for several years and is viewed as an expert in the field. In recent years, EERC researchers have been in the forefront of advancing the understanding of mercury chemistry, measurement, transformations, solid–gas interactions, and the development of control technologies.

VALUE TO NORTH DAKOTA

A major challenge facing North Dakota lignite-fired power plants is the control of mercury emissions. The mercury species in combustion flue gases produced from North Dakota lignite plants is primarily elemental and much more difficult to control than oxidized mercury forms. The project is aimed at evaluating the potential of using SCR catalysts to oxidize Hg^0 species at North Dakota power plants. Currently, SCR catalysts are used for NO_x reduction at power plants that fire higher-ranked bituminous coals and have shown some potential to oxidize mercury. Testing conducted at power plants firing subbituminous coals have shown the potential to cause SCR catalyst blinding due to high alkali and alkaline-earth ash species and decreased ability to oxidize mercury. No data exist on the potential blinding effects of North Dakota lignite on SCRs or on the ability of the SCR catalyst to oxidize mercury over an extended period of time.

MANAGEMENT

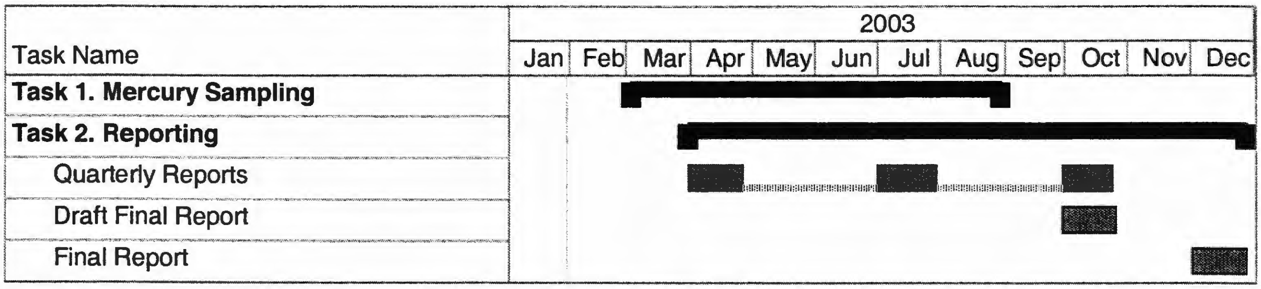
Mr. Jason Laumb will act as project manager with the assistance of Dr. Steven Benson. Mr. John Pavlish will contribute in an advisory role to the project.

Mr. Laumb is currently managing the existing SCR catalyst blinding project and will lead the coordination of efforts to facilitate the mercury sampling to be conducted under the proposed project. Dr. Benson will oversee the project activities and provide guidance in the interpretation of data analysis for the project. Dr. Benson is an expert in the field of fuel conversion, ash behavior issues, and the fate and formation of toxic trace elements. Dr. Benson is very knowledgeable on mercury issues and has over 20 years of experience in energy research. His primary duties to the project will be to oversee and lead the technology development efforts, with an emphasis on fundamental research that will lead to design of effective control technologies.

Mr. Pavlish will serve in an advisory role to the project. Mr. Pavlish has over 15 years of experience working with various power plant systems. He is also the Director of the Center for Air Toxic Metals℠ (CATM℠) program at the EERC. CATM℠ is a multiyear, multimillion dollar program aimed at researching critical issues involving trace metals, in particular, mercury.

Resumes of key personnel are included in Appendix A.

PROJECT TIME LINE



BUDGET

The budget outlining the costs for the project is included. The total cost of the project is $100,000.

MATCHING FUNDS

The funds requested are broken down as follows:

Total Project Cost	$100,000
EERC–DOE JSRP	$40,000
NDIC	$30,000
Utility Support	$30,000

The list of proposed utility sponsors includes Basin Electric Power Cooperative, Great River Energy, Minnkota Power Cooperative Inc., Montana–Dakota Utilities Co., and Otter Tail Power Company. The amount requested from each utility sponsor is $6000 for a total of $30,000. The request from the North Dakota Industrial Commission (NDIC) is $30,000. Upon receipt of commitments from the utility participants and NDIC, formal approval will be requested from the U.S. Department of Energy (DOE) to utilize $40,000 from the EERC–DOE Jointly Sponsored Research Program (JSRP). Three items are required from each utility sponsor as well as NDIC for inclusion in the EERC proposal to DOE:

- A formal commitment to the project. This can be a letter of commitment, a purchase order, or a signed contract.
- A biographical sketch or resume for the project manager or key technical contributor to the project for each sponsor.
- A short overview of each sponsor's entity.

TAX LIABILITY

None.

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BUDGET

IMPACT OF SCR CATALYST ON MERCURY OXIDATION IN LIGNITE-FIRED COMBUSTION SYSTEMS
MULTI-CLIENT/NDIC/DOE
PROPOSED START DATE: 03/01/2003
EERC PROPOSAL #2003-0068-R1

		MULTI-CLIENT		NDIC		DOE		TOTAL	
CATEGORY		**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**	**HRS**	**$COST**
TOTAL DIRECT LABOR		322	$ 8,460	322	$ 8,460	408	$ 10,946	1,052	$ 27,866
FRINGE BENEFITS - % OF DIRECT LABOR	54%		$ 4,568		$ 4,568		$ 5,911		$ 15,047
TOTAL LABOR			$ 13,028		$ 13,028		$ 16,857		$ 42,913
OTHER DIRECT COSTS									
TRAVEL			$ 855		$ 855		$ 1,710		$ 3,420
COMMUNICATION - PHONES & POSTAGE			$ 95		$ 95		$ 110		$ 300
OFFICE (PROJECT SPECIFIC SUPPLIES)			$ 108		$ 108		$ 152		$ 368
SUPPLIES			$ 166		$ 166		$ 418		$ 750
GENERAL (FREIGHT, FOOD, MEMBERSHIPS, ETC.)			$ 50		$ 50		$ 200		$ 300
FEES			$ 4,929		$ 4,929		$ 7,635		$ 17,493
TOTAL OTHER DIRECT COST			$ 6,203		$ 6,203		$ 10,225		$ 22,631
TOTAL DIRECT COST			$ 19,231		$ 19,231		$ 27,082		$ 65,544
FACILITIES & ADMIN. RATE - % OF MTDC		56%	$ 10,769	56%	$ 10,769	47.7%	$ 12,918	VAR	$ 34,456
TOTAL ESTIMATED COST			$ 30,000		$ 30,000		$ 40,000		$ 100,000

BUDGET NOTES

ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

Background

The EERC is an independently organized multidisciplinary research center within the University of North Dakota (UND). The EERC receives no appropriated funding from the state of North Dakota and is funded through federal and nonfederal grants, contracts, or other agreements. Although the EERC is not affiliated with any one academic department, university academic faculty may participate in a project, depending on the scope of work and expertise required to perform the project.

The proposed work will be done on a cost-reimbursable basis. The distribution of costs between budget categories (labor, travel, supplies, equipment, subcontracts) is for planning purposes only. The principal investigator may, as dictated by the needs of the work, reallocate the budget among approved items or use the funds for other items directly related to the project, subject only to staying within the total dollars authorized for the overall program. The budget prepared for this proposal is based on a specific start date; this start date is indicated at the top of the EERC budget or identified in the body of the proposal. Please be aware that any delay in the start of this project may result in an increase in the budget. Financial reporting will be at the total project level.

Salaries and Fringe Benefits

As an interdisciplinary, multiprogram, and multiproject research center, the EERC employs an administrative staff to provide required services for various direct and indirect support functions. Direct project salary estimates are based on the scope of work and prior experience on projects of similar scope. Technical and administrative salary charges are based on direct hourly effort on the project. The labor rate used for specifically identified personnel is the current hourly rate for that individual. The labor category rate is the current average rate of a personnel group with a similar job description. For faculty, if the effort occurs during the academic year and crosses departmental lines, the salary will be in addition to the normal base salary. University policy allows faculty who perform work in addition to their academic contract to receive no more than 20% over the base salary. Costs for general support services such as grants and contracts administration, accounting, personnel, and purchasing and receiving, as well as clerical support of these functions, are included in the EERC facilities and administrative cost.

Fringe benefits are estimated on the basis of historical data. The fringe benefits actually charged consist of two components. The first component covers average vacation, holiday, and sick leave (VSL) for the EERC. This component is approved by the UND cognizant audit agency and charged as a percentage of direct labor for permanent staff employees eligible for VSL benefits. The second component covers actual expenses for items such as health, life, and unemployment insurance; social security matching; worker's compensation; and UND retirement contributions.

Travel

Travel is estimated on the basis of UND travel policies, which include estimated General Services Administration (GSA) daily meal rates. Travel includes scheduled meetings and conference participation as indicated in the scope of work.

Communications (phones and postage)

Monthly telephone services and fax telephone lines are generally included in the facilities and administrative cost. Direct project cost includes line charges at remote locations, long-distance telephone, including fax-related long-distance calls; postage for regular, air, and express mail; and other data or document transportation costs.

Office (project-specific supplies)

General purpose office supplies (pencils, pens, paper clips, staples, Post-it notes, etc.) are provided through a central storeroom at no cost to individual projects. Budgeted project office supplies include items specifically related to the project; this includes duplicating and printing.

Data Processing

Data processing includes items such as site licenses and computer software.

Supplies

Supplies in this category include scientific supply items such as chemicals, gases, glassware, and/or other project items such as nuts, bolts, and piping necessary for pilot plant operations. Other items also included are supplies such as computer disks, computer paper, memory chips, toner cartridges, maps, and other organizational materials required to complete the project.

Instructional/Research

This category includes subscriptions, books, and reference materials necessary to the project.

Fees

Laboratory and analytical fees are established and approved at the beginning of each fiscal year, and charges are based on a per sample or hourly rate depending on the analytical services performed. Additionally, laboratory analyses may be performed outside the University when necessary.

Graphics services fees are based on an established per hour rate for overall graphics production such as report figures, posters for poster sessions, standard word or table slides, simple maps, schematic slides, desktop publishing, photographs, and printing or copying.

Shop and operation fees are for expenses directly associated with the operation of the pilot plant facility. These fees cover such items as training, safety (protective eye glasses, boots, gloves), and physicals for pilot plant and shop personnel.

General

Freight expenditures generally occur for outgoing items and field sample shipments.

Membership fees (if included) are for memberships in technical areas directly related to work on this project. Technical journals and newsletters received as a result of a membership are used throughout development and execution of the project as well as by the research team directly involved in project activity.

General expenditures for project meetings, workshops, and conferences where the primary purpose is dissemination of technical information may include costs of food (some of which may exceed the institutional limit), transportation, rental of facilities, and other items incidental to such meetings or conferences.

Facilities and Administrative Cost

The facilities and administrative rate (indirect cost rate) included in this proposal is approved by the Department of Health and Human Services. Facilities and administrative cost is calculated on modified total direct costs (MTDC). MTDC is defined as total direct costs less individual items of equipment in excess of $5000 and subcontracts/subgrants in excess of the first $25,000 for each award.