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THE NORTH AMERICAN COAL CORPORATION

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Clifford R. Miercort
President and
Chief Executive Officer

March 31, 1993

State of North Dakota
The Industrial Commission
State Capitol
Bismarck, North Dakota 58505

ATTENTION: Lignite Research Program

Dear Lignite Council/Research Members:

Enclosed is the application of The North American Coal Corporation for a grant from the North Dakota Lignite Research Fund. By this application The North American Coal Corporation hereby commits itself to complete the project as described in the application should the Industrial Commission of North Dakota make the grant requested by the application.

The applicant certifies that all information contained in the application is true to the best of the applicant's knowledge, and acknowledges the right of the North Dakota Industrial Commission to modify or terminate any subsequent agreements with applicant if the Commission becomes aware of any material misrepresentation contained in this application.

Clifford R. Miercort
President and Chief Executive Officer

Clifford R. Miercort
Signature

CRM/ml

Enclosure

ADDITIVE EVALUATION FOR EMISSIONS CONTROL AND MITIGATION OF BOILER FOULING AND SLAGGING

A Research Proposal Submitted
to the North Dakota Industrial Commission
by The North American Coal Corporation

Principal Investigator:

Greg F. Weber
Research Supervisor
Energy & Environmental Research Center
University of North Dakota

Date: March 31, 1993

Amount Requested: $27,000

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ABSTRACT

The purpose of this research will be to evaluate the addition of proprietary chemical compounds to the lignite fuel and/or gas stream to reduce SO_2 and NO_x emissions.

The 1990 Clean Air Act Amendments will force most, if not all, utilities to reevaluate their strategies for meeting current as well as future emission limits for sulfur dioxide (SO_2) and NO_x. In order to meet the 1.2-lb SO_2/MM Btu standard by the year 2000, the general approach would most likely be installation of high capital cost, of questionable efficiency. For most utilities, unit-specific issues will dictate emission control strategies.

As a result of stricter limits on the emissions of SO_2 and NO_x from fossil fuel-fired combustion systems, significant opportunities exist for commercially demonstrated as well as developing emission control technologies including fuel switching. The ultimate goal is to meet the stricter emission limits at the least cost.

This proposed research will utilize equipment at the Energy & Environmental Research Center to perform Task A of the proposed project description. Only Task A will be conducted at this time to determine the success of the additive to reduce SO_2 and NO_x emissions while firing in the EERC combustion test facility.

PROJECT SUMMARY

The overall objective of the activities outlined in this proposal is to evaluate thoroughly a proprietary chemical additive and its potential for controlling acid gas emissions. Subsequent phases of testing are planned to evaluate boiler slagging and fouling problems. Specific goals of the overall project include the following:

- To evaluate the additive's potential to reduce SO_2 emissions.
- To evaluate the additive's potential to reduce NO_x emissions.
- To determine the additive's effect on heat-transfer surface fouling and slagging.
- To begin developing an understanding of the mechanisms responsible for reduced acid gas emissions as well as impacts on fouling and slagging tendencies.

PROJECT DESCRIPTION

The proposed scope of work is divided into four tasks to allow for a stepwise approach to the evaluation, with appropriate decision points prior to proceeding with subsequent tasks. Only Task A will be undertaken at this time. Task A will involve a series of short-term tests and is simply intended to demonstrate the potential for the additive to control sulfur dioxide (SO_2) and nitric oxide (NO_x) emissions.

The coal and additives used during the experimental program will be selected and supplied to the EERC by The North American Coal Corporation (NAC). Surplus additives not used during the experimental effort will be returned to NAC. Surplus coal will be retained in

EERC storage facilities for subsequent use on other projects or be properly disposed. EERC personnel anticipate needing 10 to 20 pounds of additive and roughly 5000 pounds of coal, assuming a heating value of 7000 Btu/lb as-fired.

Task A - Additive Screening Tests for Emissions Control

The purpose of Task A is to determine whether the additive will reduce emissions of SO_2 while firing coal in the EERC combustion test facility. Prior to initiating the experimental activities, it will be necessary to design and build additional cooled surface for the convective pass to provide adequate metal surface in the flue gas stream for the additive to contact. One section of the flue gas duct in the convective pass zone would allow for installation of air-cooled tubes, resulting in an increase of cooled surface from roughly 1 ft^2 to 3-5 ft^2. Material of construction would be stainless steel unless otherwise specified. In addition, the reheat section of the system will contain 2.5 ft^2 of steam-cooled surface. Surface temperatures in the convective pass will be roughly 1000° F, and reheat surface temperatures will be roughly 750° F.

Design options for the required metal surface would be discussed with NAC for their input and approval prior to construction. During the December 3 and 22, 1992, discussions NAC stressed the need for adequate metal surface in order for the additive to work properly.

Prior to performing the initial series of additive injection tests, it will be important to characterize the additive using thermogravimetric analysis (TGA). The analysis to be completed will determine additive weight loss as a function of temperature under an inert atmosphere as well as phase changes as a function of temperature up to 1600° C. It will be important to review this

information prior to selecting the additive injection locations to be used during the pilot-scale additive injection tests.

The experimental approach for the initial additive injection tests will involve preheating the combustion test facility on natural gas for a 6- to 8-hour period prior to initiating coal firing. Once coal firing has been established, the combustor will be operated for a 1- to 2-hour period in order to establish baseline SO_2 and NO_x emissions prior to beginning the additive injection tests.

Task A will require a minimum of two days of combustor operation to complete six additive injection test periods. During the first day, three test periods 2-3 hours in length will be completed using a constant additive injection rate and three injection locations. The injection location options include the coal feed, the top of the combustor, and between the convective pass and the reheater heat-transfer surfaces.

The additive injection rates suggested during our December 17, 1992, telephone conversation included mass ratios of 1:10, 1:20, and 1:30 pounds of additive per pound of SO_2 in the flue gas. Assuming the coal used during these tests will be a North Dakota lignite containing 1.0 wt% sulfur with a heating value of 7000 Btu/lb, the additive feed rates would range from 24 to 71 grams/hour. During the first day of testing, the higher additive feed rate will be introduced at the three injection locations to maximize the potential for a significant change in SO_2 emissions.

The second day of operation will include three additive injection tests at a single location with three additive feed rates. The additive injection location will be selected based on the results

from the first day of operation. However, the first test period on the second day would attempt to duplicate the results from one of the three test periods completed the first day. Although only two days of testing are specifically planned, the budget for Task A was prepared assuming a third day of testing may be necessary as a contingency. A third day of testing would only take place if the results of the first two days of effort indicated a need for additional test periods and NAC authorized the additional effort.

STANDARDS OF SUCCESS

Project reporting requirements will be limited to a brief letter report summarizing the results from Task A experimental activities, including recommendations concerning completion of Tasks B and C, and a final project report summarizing results for Task A.

BACKGROUND

The UND EERC is one of the world's major energy and environmental research organizations. Since its founding in 1951, the EERC has conducted research, testing, and evaluation of fuels, combustion and gasification technologies, emissions control technologies, ash use and disposal, analytical methods research, groundwater, waste-to-energy, and advanced environmental control systems research. 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 has conducted extensive research on the engineering aspects and environmental effects of carbon-based fuels combustion and gasification. Specific program areas include ash and slag chemistry, trace metals in fuels, inorganic transformations, ash deposition, coal combustion chemistry, corrosion/erosion mechanisms, fuels evaluation, fluidized-bed combustion, gas turbines, diesels, slurry combustion, SO_s control, NO_x control, particulate control, hot-gas cleanup, clean coal technologies, advanced power systems, process development, gasification/combined cycle systems research, waste-to-energy conversion, and synthetic fuels investigations.

The EERC has a wide range of analytical capabilities that have been tailored to fuels, ash, and other materials associated with energy and environmental issues; these techniques include a full range of organic analysis, inorganic analysis, surface and mineralogical analysis, thermal analysis, and physical analysis. Research has been performed in order to develop methods to determine the association, size, and composition of ash-forming constituents in fuels and conversion residues. Analytical techniques are now available to determine the distribution of phases in fuels, fly ashes, deposits, slags, ash utilization materials, soils, and other materials. Analytical methods development is an ongoing research activity at the EERC. The development of new analysis techniques has been an integral part of several of the EERC's most successful projects. Mathematical modeling of processes such as ash formation, trace metals partitioning, and deposition in gasification and combustion systems is also an ongoing research area at the EERC.

Extensive research on the inorganic and mineral components in fuels and conversion residues has been conducted at the EERC; these data have been related to the potential for ash

utilization and environmental aspects of ash disposal. Research efforts in the area of ash utilization and disposal have been focused on 1) detailed characterization of fuels, ashes, and utilization products and; 2) carefully controlled experiments and tests to relate the materials chemical and physical properties to the formation of ashes, deposits, and agglomerates.

QUALIFICATIONS

GREG F. WEBER
Senior Research Manager
Process Engineering
Energy and Environmental Research Center
University of North Dakota
P.O. Box 9018, Grand Forks, North Dakota 58202-9018 USA
Phone (701) 777-5000 Fax (701) 777-5181

Principal Areas of Expertise

Development of public and private sector projects focused on solving problems associated with the operation of conventional combustion and emissions control systems as well as the development of advanced power and emissions control systems. Specific activities have included proprietary and nonproprietary projects and single and multiclient projects. Emphasis has been placed on the development of joint venture multiclient projects involving private industry, government agencies, and academia. In all cases, the cradle-to-grave approach to process development makes use of a multidisciplinary project team to meet project objectives.

Technical expertise includes development of emissions control strategies for coal-based, especially low-rank coal, combustion systems. Technology development has included sulfur dioxide control using calcium- and sodium-based alkali systems, conventional particulate control with electrostatic precipitators and fabric filters, hot-gas particulate control using filtration, the control of nitrogen species using catalytic and noncatalytic processes, the measurement and control of air toxics, and the evaluation of control technology impacts on boiler system operability.

Technology transfer activities have included seminar presentations, supervision of undergraduate and graduate students, participation in and organization of international conferences on low-rank coal utilization and emissions control, preparation and presentation of conference papers, and development and presentation of training materials. Recent examples involving international activities include a January 1992 presentation at the "Coal Characterization and Boiler Seminar" held in Jakarta, Indonesia.

Education

M.S., Chemical Engineering, University of North Dakota, 1982.
B.A., Chemistry, Dickinson State College (North Dakota), 1978.

Professional Experience

1992 - Senior Research Manager, Process Engineering, Energy and Environmental Research Center, University of North Dakota, Grand Forks, North Dakota. Responsibilities include planning, staffing, budgeting, supervision, execution, and publication of research findings for projects related to the utilization of fossil fuels, specifically low-rank coal. Specifically responsible for development and execution of projects that address problems in conventional combustion systems, evaluate advanced power systems, and address all aspects of flue gas emissions control (sulfur dioxide, nitric oxide, particulate, and air toxics) including hot-gas cleanup.

1983-92 Research Supervisor, Environmental Systems, Combustion and Environmental Systems Research Institute, Energy and Environmental Research Center, University of North Dakota, Grand Forks, North Dakota.

1982-83 Supervisor, Technical Support Group, EG&G Washington Analytical Services Center, Inc., Grand Forks, North Dakota.

1981-82 Test Engineer, Technical Support Group, EG&G Washington Analytical Services Center, Inc., Grand Forks, North Dakota.

1980-81 Shift Supervisor, Operations Group, EG&G Washington Analytical Services Center, Inc., Grand Forks, North Dakota.

1978-80 Graduate Teaching Assistant, Department of Chemical Engineering, University of North Dakota, Grand Forks, North Dakota.

1977-78 Lab Technician, Northland Oil and Refining Company, Dickinson, North Dakota.

Publications

Authored and coauthored over 40 publications.

JAY R. GUNDERSON
Research Engineer, Combustion Systems

Principal Areas of Expertise

Coal combustion technology including coal/water fuel combustion and ash fouling.

Education

M.S., Studies, Chemical Engineering, University of North Dakota, 1987-present.
B.S., Chemical Engineering, University of North Dakota, 1987.

Professional Experience

July 1988 – Present: Research Engineer, Combustion and Environmental Systems Research Institute, Energy and Environmental Research Center, University of North Dakota, Grand Forks, North Dakota.

Responsibilities involve pilot-scale combustion projects for residential-, commercial-, and utility-scale applications of coal-fired combustion systems, including ash fouling and fuel characterization. Duties include documentation and reporting of pilot-scale testing results and presentation of those results at national and international conferences.

January – June 1988: Research Assistant, Combustion and Environmental Systems Research Institute, Energy and Mineral Research Center, University of North Dakota, Grand Forks, North Dakota.

Responsibilities involved the development of a coal/water fuel-fired residential- and commercial-scale furnace.

Professional Memberships

- American Institute of Chemical Engineers
- Alpha Tau Omega Fraternity

Publications and Presentations

- Has coauthored numerous publications

VALUE TO NORTH DAKOTA

The enactment of the 1990 Clean Air Act will force most utilities, including those in North Dakota, to reevaluate their strategies to reduce SO_2 and NO_x emissions. It is hoped the research results will allow the development of an additive to reduce the cost of SO_2 and NO_x emission control in power plants and chemical processes such as the Great Plains Gasification Plant. If so it will improve the cost competitiveness of North Dakota electricity on the electric distribution grid. This will result in the continued employment of North Dakota residents.

MANAGEMENT

The principal investigatior will personally oversee the entire project to completion. Project evaluation points will correspond to the proposed research timetable.

TIMETABLE

The project schedule assumes a project start date of June 1, 1993, and anticipates a project completion date of July 31, 1993. This one-month time frame will be necessary to allow sufficient time for thoroughly evaluating data from Task A prior to proceeding to any future task and completion of the final project report. The exact project schedule will depend on completion of contractual negotiations and prior EERC commitments.

BUDGET

The estimated cost for Task A is presented in the attached budget. The basis for the fringe benefit and indirect cost rates were part of EERC's proposal. The proposed work will be done on a time-and-materials basis.

LABOR	LABOR CATEGORY	HOURLY RATE		TASK A HOURS	$ COST
M. Jones	Principal Scientist	$39.66	5%	16	$635
M. Mann	Principal Scientist	$29.33		0	$0
G. Weber	Principal Scientist	$31.25		80	$2,500
S. Benson	Principal Scientist	$31.73		8	$254
C. Zygarlicke	Res. Scientist III	$22.24		0	$0
J. Gunderson	Res. Scientist II	$18.27		136	$2,485
K. Katrinak	Res. Scientist II	$16.83		0	$0
D. McCollor	Res. Scientist II	$20.12		0	$0
D. Toman	Res. Scientist II	$19.19		0	$0
D. Evenstad	Res. Scientist I	$16.47		0	$0
J. Larsien	Res. Technician III	$19.01		40	$760
R. Timpe	Res. Scientist III	$23.81		8	$190
E. O'Leary	Res. Technician II	$13.55		0	$0
R. Schulz	Res. Technician II	$14.85		40	$594
----------	Facility Manager	$31.25		8	$250
----------	Pilot Plant Op. IV	$16.41		40	$656
----------	Pilot Plant Op. III	$13.17		200	$2,634
Machine Shop	Res. Equip. Mech.	$13.82		60	$829
Inst. Shop	Res. Equip. Mech.	$13.82		16	$221
M. McLaughlin	Res. Technician I	$8.03		8	$64
B. Beckstead	Res. Technician I	$7.50		0	$0
J. Bieber	Res. Technician I	$8.90		0	$0
----------	Student	$5.80		0	$0
----------	Office Services	$8.88		40	$355
				700	$12,427
ESCALATION ABOVE CURRENT BASE	5%			5%	$621
TOTAL DIRECT LABOR					$13,048
FRINGE BENEFITS - % OF DIRECT LABOR		46%			$6,002
TOTAL LABOR BASED CHARGES					$19,050
OTHER DIRECT COSTS					
GENERAL SUPPLIES AND EQUIPMENT <$500					$1,500
SUBCONTRACTS					
NORTHWEST RESEARCH-S.SELLE @ $62.50/HR.					$750
OTHER					
COMMUNICATION - PHONES AND POSTAGE					$100
OFFICE SUPPLIES, DUPLICATING					$50
DATA PROCESSING					$100
FEES					
COMBUSTION MAINTENANCE FEE					$3,800
PARTICULATE SAMPLING FEES					$882
SHOP/OPERATIONS SUPPORT CHARGE @$0.85/HR					$269
COAL ANALYSIS LABORATORY					$1,543
NATURAL MATERIALS ANALYTICL RES. LAB					$5,228
ANAL. RES. LAB-ATOMIC ABS. W/PREP-SODIUM @ $55/HR					$960
GRAPHIC ARTS COST CENTER @ $24/HOUR					$480
PROFESSIONAL STAFF CLERICAL SUPPORT @$.62/HR					$208
FUELS RESEARCH LABORATORY					$0
TOTAL OTHER					$13,620
TOTAL OTHER DIRECT COST					$15,870
TOTAL DIRECT COST = LABOR BASED + TOTAL OTHER DIRECT					$34,920
INDIRECT COST - % OF MTDC*			51.0%		$17,809
TRAVEL & LODGING					$2,000
TOTAL ESTIMATED COST					$54,729

The level of funding as presented in the budget is the amount necessary to meet the objectives. The research will probably not be initiated without this funding.

MATCHING FUNDS

The North American Coal Corporation (NAC) is requesting a matching grant in the amount of 50% of the cost of the defined research up to a maximum of $27,000 from the research fund. NAC will fund the other 50%.

TAX LIABILITY

The North American Coal Corporation does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.