Energy & Environmental Research Center

Fuels & Process Chemistry Research Institute
ND Mining & Mineral Resources Research Institute
Combustion & Environmental System Research Institute

Box 8213, University Station / Grand Forks, North Dakota 58202-8213 / Phone: (701) 777-5000 / Fax: 777-5181

September 28, 1990

Mr. Tim Kingstad, Secretary
North Dakota Lignite Council
North Dakota State Land Department
State Capitol Building
Bismarck, ND 58502

Dear Mr. Kingstad:

It is our pleasure to submit this proposal to the North Dakota Lignite Research Council for consideration in Round 6 of project selection. We look forward to the successful programs of the Council advancing and enhancing the many ways in which North Dakota lignite can serve the region's and nation's energy and material needs, now and in the future.

This proposal requests funds as a part of a multiclient program entitled "Project CFB." The objective of this program is to design and operate a circulating fluidized-bed combustion test facility to obtain comprehensive, reliable, and accessible data for use by the industrial and utility sectors. Data generated using this test facility will help both the producer and user of North Dakota lignite by providing the information needed to use high-slagging, high-fouling North Dakota lignite without paying the capital and operating penalties associated with lignite usage in conventional coal-fired systems.

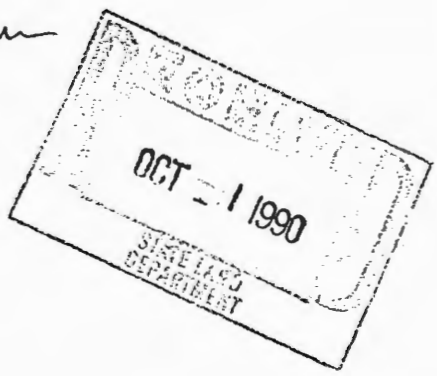
Funding for a baseline program has been received from the North Dakota Lignite Research Council. At the request of the Advisory Council, the scope of work for the program has been expanded, and additional monies are required. This request is for $50,000 and would bring the state's contribution to this timely and much-needed research to 10% of the $1,005,000 budget for the overall program. The $1,005,000 budget assumes all committed and requested funds will be realized.

I look forward to the Council's positive endorsement of this proposal.

Sincerely,

Michael D. Mann

Michael D. Mann
Research Supervisor
Combustion Systems



Alice T. Clark

for Alex Kotch, Director
Office of Res. & Prog. Development

MDM/yjq-f

Enclosures

PROJECT CFB

The Design and Operation of a CFBC Test Facility to Generate Comprehensive, Reliable, and Accessible Data for Utility and Industrial Clients

Submitted to:

North Dakota Lignite Council
P.O. Box 2277
Bismarck, ND 58502

Submitted by:

Michael D. Mann, Principal Investigator

Energy and Environmental Research Center
University of North Dakota
Box 8213, University Station
Grand Forks, North Dakota 58202

October 1, 1990

Amount Requested: $50,000

Michael D. Mann
Michael D. Mann
Principal Investigator

Alice T. Clark
for Alex Kotch, Director
Office of Research and
Program Development

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PROJECT CFB

The Design and Operation of a CFBC Test Facility to Generate Comprehensive, Reliable, and Accessible Data for Utility and Industrial Clients

SUMMARY

Project CFB is a multiclient study to design and operate a circulating fluidized-bed combustion (CFBC) test facility to provide comprehensive, reliable, and accessible data for utility and industrial applications.

Circulating fluidized-bed combustion is a growing technology that is rapidly gaining acceptance for the combustion of a wide range of coals. Extremely low levels of gaseous emissions of SO_x and NO_x can be achieved using this technology. Using sorbents in the bed for SO_2 control and low operation temperatures to limit NO_x production, this technology has the potential to meet all proposed emission standards when burning North Dakota lignites. At this time, the only comparable test facilities available in the United States are operated by boiler vendors.

The ability to operate with a wide variety of coals is one of the notable characteristics of CFBC. North Dakota lignites have been labeled as coals with ash deposition problems. This results from high levels of sodium found in many of these fuels. Fluid-bed technology offers the opportunity to burn these high-sodium fuels without the capital equipment and operating cost penalties normally associated with lignite-fired plants.

The project was initiated on May 16, 1988. The scheduled completion date is April 30, 1991. The scope of work for the project has been expanded, based upon recommendations of the Advisory Committee, and a revised budget to accomplish these revisions is $1,005,000. The expanded program adds versatility and flexibility to the unit and will improve the ability of the pilot unit to mimic real-life units. It was also suggested that the test matrix be expanded to include two sorbents and four coals.

Sponsor funding at this time includes $100,000 from Northern States Power, $50,000 from Consolidated Edison, $75,000 from Texas Utilities, $75,000 from the Electric Power Research Institute, $230,000 from the Department of Energy, $100,000 from the Empire State Electric Energy Research Corporation, $75,000 from ARCO Coal Company, $100,000 from Otter Tail Power Company, $50,000 from Premier Refractories, and $50,000 from the North Dakota Lignite Research Council. Additional funding is anticipated from EPRI, DOE, NSP, and ARCO Coal Company.

During the first phase of the project, an extensive literature review and design effort was undertaken. The result of this effort was the design of a CFBC pilot facility capable of burning any rank of coal while simulating the design configuration of any of the major boiler vendors. Construction of the unit was completed in May 1990, with initial shakedown baseline testing performed in June and July. The most important part of this study, testing of the candidate coals, is planned for December 1990 through February 1991.

1.0 OBJECTIVES

Project CFB is a multiclient study to design and operate a circulating fluidized-bed combustion test facility that will provide comprehensive, reliable, and accessible data for utility and industrial applications. In meeting this objective, the program will establish an independent laboratory for the development of circulating fluidized-bed combustion design and operational data. Being free from boiler vendor bias, results from this study will give those industries and utilities considering retrofit or new construction a total information package to evaluate the various CFB options available. This will be the only independent test facility of this type in the United States.

Project CFB is expected to be beneficial to both the producers and users of North Dakota lignite. Circulating fluidized-bed combustion offers a method of utilizing high-sodium coals without the serious implications of slagging and fouling. SO_2 and NO_x emission limits can easily be met without the need for expensive back-end cleanup devices. Because CFB has the capabilities to burn lignite efficiently, the impetus for using coals from other regions such as the Powder River Basin is greatly reduced.

Circulating fluidized-bed combustion is a promising candidate for new construction and retrofit applications on the institutional, industrial, and utility scale. The information generated during this program will allow these sectors to accurately evaluate various CFB options available to choose a strategy that can provide them with the most efficient method to generate steam or power, while utilizing North Dakota lignites. Thus both the producer and user of North Dakota lignite can realize the benefits of this program. Other benefits of participating in the program include:

- Rapid access to a compilation of available literature on the current state of knowledge on all aspects of CFBC.

- Cost-effective information from an independent source at a fraction of the cost available to a single company.
- An opportunity to assist in the selection of coals to be tested and the design of test matrices.
- Information to make prudent choices for future generation capacity.
- The ability to effect rapid transfer of information and data through consultation with UNDEERC staff and sponsor personnel.
- Interaction with other sponsors and with personnel interested in CFBC.

2.0 BACKGROUND

Circulating fluidized-bed combustion (CFBC) is a growing technology that has rapidly gained industrial acceptance for the combustion of coal and other fuels in the last couple of years. Two of the larger current users of operational industrial-scale CFBC systems include the Scott Paper Company (650,000 lbs/hr) in Chester, Pennsylvania, and General Motors Corporation (300,000 lbs/hr) in Pontiac, Michigan. On the utility scale, Colorado-Ute Electrical Association is currently engaged in demonstrating operability with its 110-MW CFBC at the Nucla Generating Station. The reason for CFBC's popularity over bubbling AFBC systems is its potential for increased limestone utilization, lower nitrous oxide emissions, greater fuel flexibility, decreased fuel feed problems, a wide range of turndown, and a decreased cross-sectional area of the combustor. These advantages mean that North Dakota lignites can be burned in a CFBC without paying the heavy capital and operational expense penalties caused by the fouling, deposition, and emissions associated with the use of lignite in conventional combustion systems.

While CFBCs are gaining rapidly in popularity, there is generally a dearth of information available to allow the engineer or user to make an educated selection on the appropriate design and operational conditions for the design fuels. The limited amount of CFBC design and operational data

available is mostly proprietary. The operational and design philosophies of CFBC vendors vary in a number of areas, including the use of an external heat exchanger (EHE), recycle rates and methods, the amount of refractory coverage required in the lower combustion section, the appropriate flue-gas velocity, the required calcium-to-sulfur ratio to meet new source performance standards (NSPS) overall heat-transfer surface area required, and solids inventory at rated capacity. Vendors also vary on the amount of turndown they will guarantee.

The University of North Dakota Energy and Environmental Research Center (UNDEERC) is one of the world's major coal research facilities. Since its founding in 1951, the Center has conducted research, testing, and evaluation of coals and associated combustion and conversion technologies. The Center's transfer from the U.S. Department of Energy to the University of North Dakota in 1983 made it possible for the Center's staff to work directly for industry to provide needed data and practical solutions for the specific problems and challenges encountered. Today, the Center is the leading organization in the United States doing contract research on the characterization and utilization of lignitic coals. The Center possesses state-of-the-art analytical equipment and extensive pilot-plant facilities, providing unique capabilities for research programs.

A research program was initiated at the Energy Research Center in 1975 for the study of fluidized-bed combustion of low-rank coals. Atmospheric fluidized-bed combustion (AFBC) research has been performed providing information on limestone utilization and sulfur capture; nitrous oxide emissions; particulate capture; combustion efficiencies; heat transfer; characterization of fluidized-bed solid waste; bed material agglomeration promoted by high-sodium coals; corrosion and/or erosion of metal surfaces in

the bed, splash zone, and convective pass; and the combustion of slurried fuels. Presently there are two AFBC test facilities at UNDEERC; both operate in the bubbling mode. They include an 18- by 18-inch square combustor, primarily being utilized for coal characterization and slurry combustion research, and an 8- by 8-inch square combustor that was designed and constructed specifically for corrosion/erosion/deposition studies. EERC has performed fluid-bed combustor work for a number of clients, including utility companies, boiler vendors, A&E firms, and government-sponsored agencies. EERC's recognition as the world's leader in low-rank coal has also led to fluid-bed contracts involving several foreign countries.

This application for funds details the expanded goals of a multiclient program to design, construct, and operate a CFBC pilot plant facility at EERC. The purpose of this program is to provide participating clients the opportunity to obtain needed design and operational information on how a CFBC system can be expected to perform with selected coals. This study is expected to benefit industrial and utility companies and North Dakota coal producers by providing the design and operational information needed to ensure an increased utilization of one of our state's greatest resources.

During the first phase of this project, an extensive literature survey of existing and planned CFBC facilities was performed. Site visits were made to operational facilities of all sizes to gather design information and further define those aspects of CFBC most needing research. Results from the literature survey and site visits were used to design a versatile pilot-scale CFBC facility. This facility is designed to burn any rank of coal and to be operated in configurations similar to any of the units currently sold by major boiler vendors. Construction of the facility was completed in May.

3.0 GOALS

The goal of this project is twofold. The first and most immediate goal is to provide the sponsor with a technical information base that can be used to evaluate the various CFB options available. A second and more long-term goal is to develop a facility, independent of vendor bias, that is readily available to the industrial and utility sectors to use as a tool for answering questions specific to their particular applications. The intended results of the program are listed below. The methodology of obtaining these results is discussed in Section 4.0.

A. Provide a centralized resource containing the following information on CFB:
   - A data base containing published information on CFB technology, with summaries for all articles included
   - Location of existing and planned pilot-, commercial-, and utility-scale facilities
   - All available CFB design and operational data from existing facilities

B. Design and construct a CFB with the following characteristics:
   - Optimal design for reliable data at a reasonable cost
   - Generic design to provide data representative of various vendor designs
   - Capabilities to vary the following parameters:
     - Superficial gas velocity
     - Operational temperature
     - Ratio of overfire to combustion air
     - Bed particle size and distribution
     - Fuel type
     - Sorbent type
     - Alkali-to-sulfur ratio
     - Operation with or without external heat exchanger
   - Capabilities to evaluate the following performance variables:
     - Environmental Performance
       - SO_2 control/sorbent addition and utilization
       - NO, NO_2, and N_2O emissions
       - CO/hydrocarbon emissions
       - Particulate collectibility
       - Waste characterization and disposal
     - Thermal Performance
       - Combustion efficiency
       - Heat transfer
       - Moisture/ash/sorbent thermal losses
       - Fouling

Operational Performance
Fouling/deposition on heat transfer surfaces
Agglomeration/sintering in bed
Coal/ash solids particle size
Erosion and corrosion potential

C. Perform parametric testing to develop baseline data on the operation of a CFB:
- Coal selection to be approved by Advisory Committee
- Statistically designed test matrix to be used
- Parameters listed above to be evaluated

D. Prepare a final report discussing the following aspects of the project:
- Summary of literature survey and data base development
- Design drawings and specifications
- Results of parametric testing
- An evaluation of the various design and operational variables considered

The Advisory Committee, made up of one representative from each sponsor, has the responsibility to review all work performed to determine whether each goal has been met according to the standard established in this prospectus.

During the first part of this program, efforts have focused on achieving the objectives laid out in Items A and B. An extensive collection of published information has been reviewed and summarized. Information on existing CFBC plants is being gathered and correlated to guide the efforts of design and test work. A preliminary design of all major components was completed and reviewed at the last Advisory Committee meeting. A preliminary test matrix was discussed during the July 1990 meeting, with the final matrix to be approved at the November meeting of the Advisory Committee. All of the objectives of Part B have been met in this design.

4.0 METHODS

The tasks outlined in the scope of work for the original grant proposal will be performed. Based on recommendations from the Advisory Committee for Project CFB, an expanded scope of work is proposed that includes changes and additions to the original equipment layout and additional parametric testing

to include limestone type as a parameter. The Advisory Committee also voted to expand the number of coals tested if funding is obtained.

4.1 Task 1 -- Technology Assessment

Task 1 has been completed and will not be changed from the original test plan.

4.2 Tasks 2 and 3 -- Design and Construction

The evolution of the design of the pilot plant equipment layout will be summarized to show the change of the scope of work for Tasks 2 and 3. EERC had originally envisioned a combustor between 12 and 18 inches in diameter. The final design of a 20-inch ID combustor resulted from discussions with various vendors and researchers and the vote of the Advisory Committee.

The original design proposed a cyclone to collect and return the solids to the combustor. However, design efforts indicated that a classical cyclone design for a unit this size would be too efficient and would give a cut point size for the recirculation solids much lower than that typical in a commercial unit. Also, once built, a cyclone does not offer the variability to look at solids cut point as a test parameter. Therefore, a more versatile particle separation device was proposed. This device combines a gravity separation chamber with an impaction device. The device is multichambered to allow a specified cut point to be achieved, independent of gas velocity and coal and sorbent characteristics.

Several sponsors have plans to burn coals that may have a high ash fouling potential. Most North Dakota lignites fall into this category. In addition, current operators of CFBC plants have indicated that fouling in the convective pass is a problem with certain fuels. Therefore, an ash fouling test section will be installed on the unit. The amount of pressure drop that may be incurred across a set of convective tubes as a result of fouling can be measured in this section.

Because this unit is designed to operate over a range of test conditions using coals with a wide range of properties, the volume of flue gas generated during a given test can vary by a factor of almost four. This means that if only one set of flue gas ducting exists, the velocity of the ash-laden flue gas could vary by the same factor. This would cause dropout of particulate matter at low velocities and could cause erosion problems at higher velocities. One of the test goals is to evaluate the collectibility of the particulate generated from CFBC. To generate this data under realistic conditions for all coals tested under all conditions, the flue gas had to be divided into three streams. At low flue gas flow rates, only one duct would be used to ensure that the proper velocity was maintained. The other two ducts would be brought on-line as the flue gas volume increased, either through increases in combustor velocity or excess air, or as a result of changing from a low-moisture to a high-moisture coal.

An additional change not anticipated in the original test plan deals with the electrical classification of the building where the test unit is located. The Grand Forks City Electrical Inspector has classified the tower where the CFBC is housed as Class I, Division 2, due to its multiple uses. Minor modifications will be made to the building to ensure it meets the proper electrical code. Electrical equipment on the test system will be compatible with this classification.

All of the above design changes have been discussed with the members of the Advisory Committee and were approved during the June 1, 1989, Sponsors' Meeting. We believe that these enhancements will greatly improve the value of the data generated from this program. Figures 1 and 2 show some of the design details of this test unit.

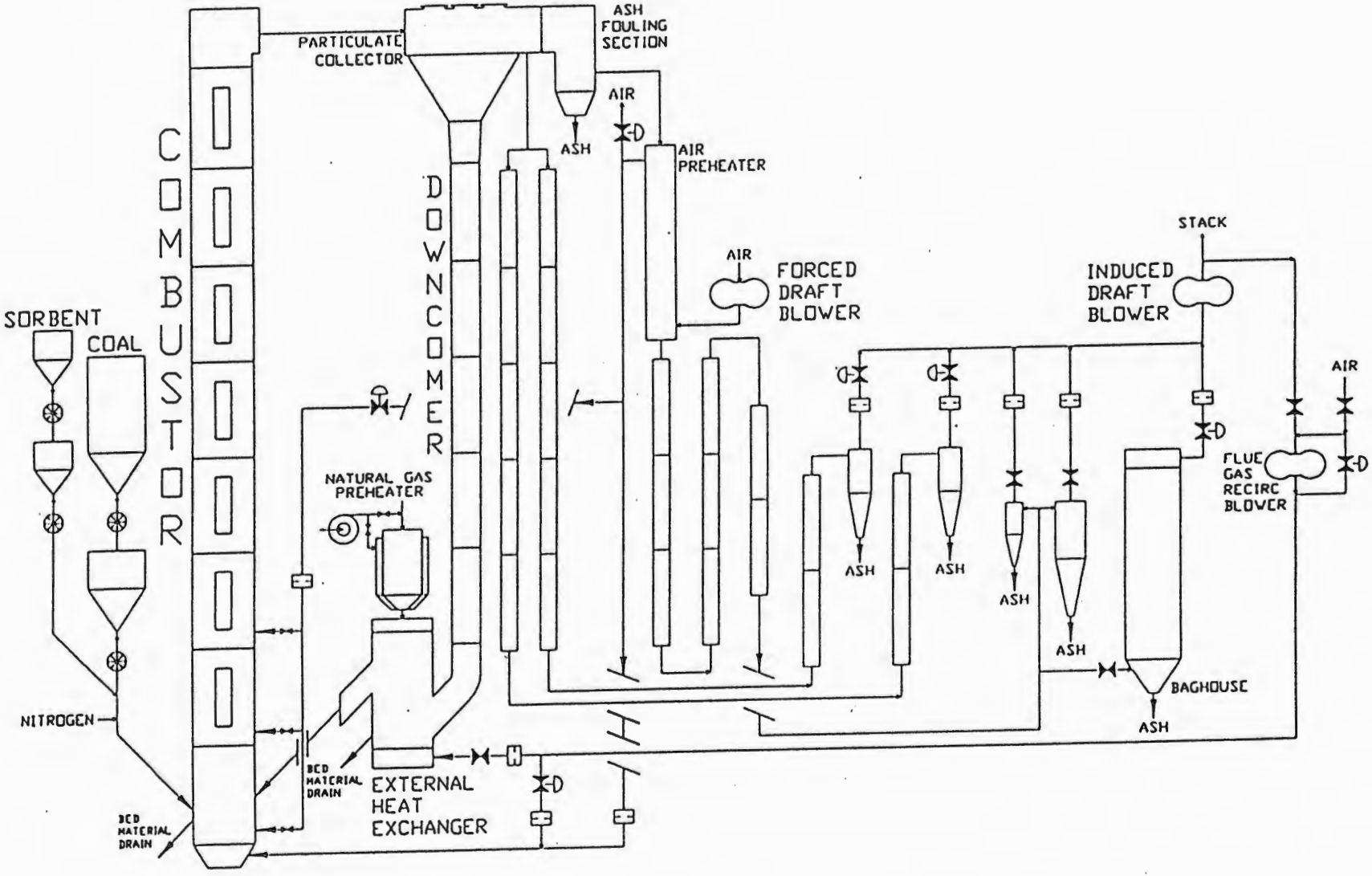

Figure 1. Schematic of EERC 1-MW_{TH} CFBC pilot plant.

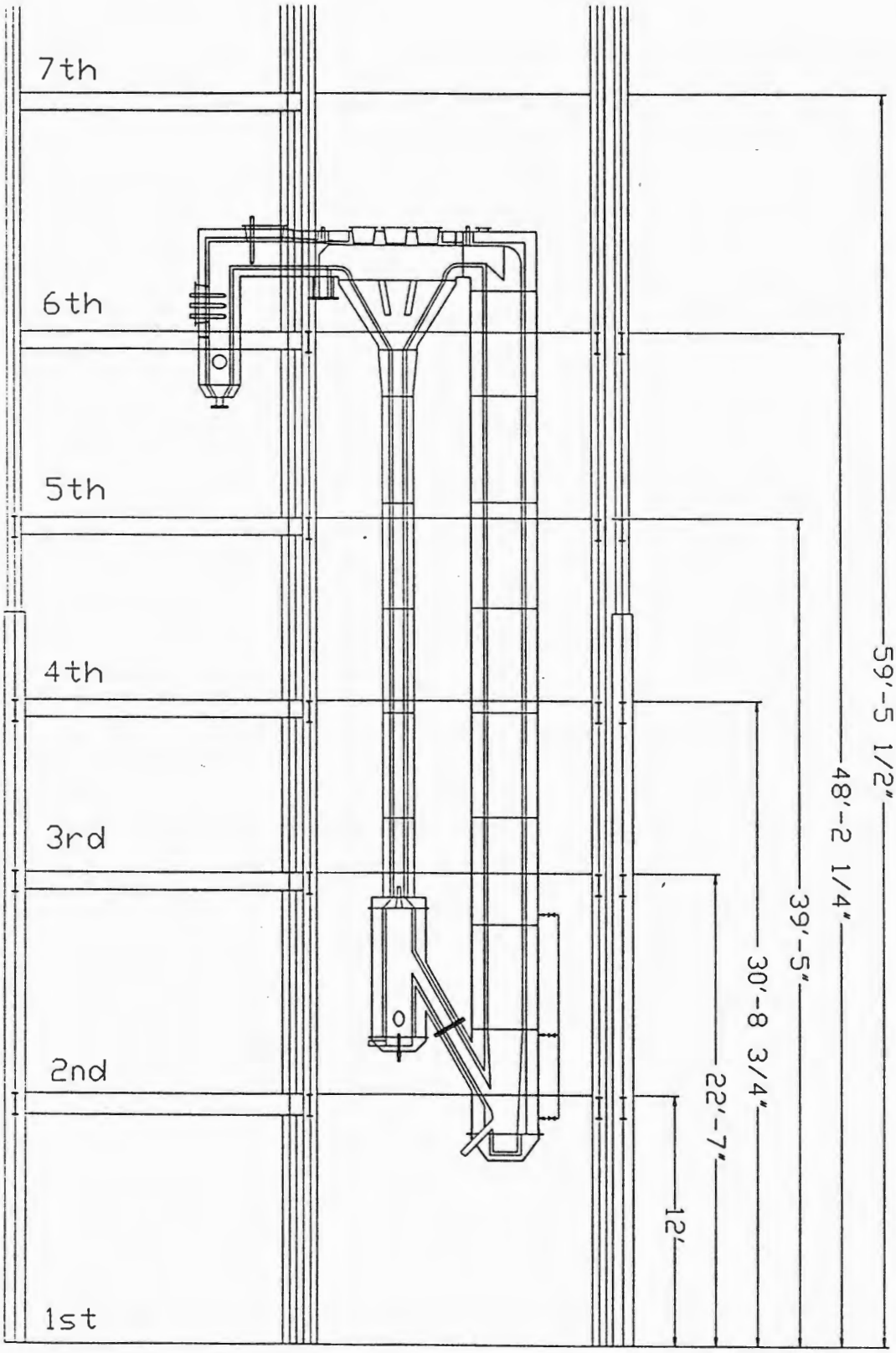

Figure 2. Layout of combustor in gasification tower.

4.3 Task 4 -- System Shakedown

No changes are planned for this task, although its duration is expected to increase due to the added complexity of the system resulting from the enhancement discussed for Tasks 2 and 3.

4.4 Task 5 -- Parametric Testing

At the November 30, 1989, meeting, members of the Advisory Committee indicated the desire to evaluate two limestones in the test matrix, in addition to the two coals planned for testing in Task 5. Therefore, a third set of tests will be performed using one of the two coals with a second limestone. The variables to be used in testing each of the coal/limestone combinations will be determined by vote of the sponsors at the next meeting. At the same meeting, the desire was indicated to burn four coals rather than the two coals proposed in the original prospectus, which will add additional tests to the test matrix. The tentative test matrix discussed at the November 30 meeting is shown in Table 1.

TABLE 1. PRELIMINARY TEST MATRIX

Test Series 1 -- Standard Fuel Test

Test No.	Temp., °F	Recirc.	Ca/S	Excess Air, %	Air Split
1.1	1550	Base	2.0	20	67:33
1.2	1450	Base	2.0	20	67:33
1.3	1650	Base	2.0	20	67:33
1.4	1550	High	2.0	20	67:33
1.5	1550	Low	2.0	20	67:33
1.6	1550	Base	1.0	20	67:33
1.7	1550	Base	3.0	20	67:33
1.8	1550	Base	2.0	50	67:33
1.9	1550	Base	2.0	20	80:20
1.10	1550	Base	2.0	20	50:50

Continued ...

TABLE 1. PRELIMINARY TEST MATRIX (continued)

Test Series 2 -- Solids Recirculation Cut Point

Test No.	Collector Efficiency	Cut Point, microns
2.1	High	150
2.2	Low	20

Test Series 3 -- Combustion Air Split/Excess Air/OFA Location

	% of Stoichiometric Air				
Test No.	Primary	Secondary	Total	Location	Primary:Secondary
3.1	96	24	120	1	80:20
3.2	80	40	120	1	67:33
3.3	60	60	120	1	50:50
3.4	100	50	150	1	67:33
3.5	63	37	100	1	67:33
3.6	96	24	120	2	80:20
3.7	60	60	120	2	50:50

Test Series 4 -- Load Control

Test No.	Velocity ft/sec	Flue Gas Recycle, %	Solids Density	Heat Removal Combustor:Ext. Heat Exchanger
4.1	23	0	Base	Base
4.2	12	0	Base	Base
4.3	16	25	Base	Base
4.4	16	0	High	Base
4.5	16	0	Low	Base
4.6	16	0	Base	100:0
4.7	16	0	Base	50:50

Test Series 5 -- Feed Material Sizing

		Sorbent Size, microns		
Test No.	Fuel Size, in.	Top	Bottom	Mean
5.1	-1/8	300	150	200
5.2	-1/2	300	150	200
5.3	-1/4	750	150	500

Test Series 6 -- Sorbent Type

Test No.	Fuel Type	Sorbent Type	Ca/S
6.1	Coal A	Limestone B	1
6.2	Coal A	Limestone B	2
6.3	Coal A	Limestone B	3

4.5 Task 6 -- Reporting

The final report will be prepared as planned and will include the additional information generated from the expanded scope of work.

5.0 SCHEDULE AND DELIVERABLES

The tentative schedule for each of the project's six tasks is presented in Table 2. Task reports are submitted to the project sponsors at the completion of each task. Monthly letter reports provide updates on the overall project status. Planning and review meetings are held every six (6) months to review work completed and to aid in the planning of subsequent tasks. The draft final report will be submitted to the project sponsors for review one month prior to the final review meeting. The reviewed and edited task reports will be major inputs into the final report.

TABLE 2. PROJECT SCHEDULE AND BUDGET

Task No.	Task Description	Schedule by Project Quarters 1 2 3 4 5 6 7 8 9	Estimated Cost ($1000)
1	Assessment of CFBC Knowledge	____*	20
2	Design	_____*	100
3	Construction	_____*	555
4	Shakedown	____*	100
5	Parametric Testing	____*	200
6	Final	0 0	30
			$1,005
	Planning and Review Meetings	# # # #	

Deliverables
* Task Reports
0 Draft Final Report & Final Report

6.0 PERSONNEL AND FACILITIES

The Principal Investigator for the project is Mr. Michael D. Mann. Mr. Mann (M.S. Chemical Engineering and M.B.A.) joined the Center in 1981 and is involved in research related to fluidized-bed combustion, ash fouling and deposition, and advanced concepts for utilizing low-rank coals. He is currently the supervisor of the Combustion Systems Group in the Combustion and Environmental Systems Research Institute and has been actively involved in coal-related studies using pilot-scale equipment for most of his career. Mr. Mann would be responsible for overall technical management of the program, including monitoring project schedules and budgets. He will spend approximately 40 percent of his time dedicated to this project.

Mr. Doug Hajicek (B.S. Mechanical Engineering) joined the Center in 1976 and is primarily involved with a program assessing the occurrence of corrosion and/or erosion in fluidized-bed combustion systems utilizing low-rank coals. He has been responsible for, as well as actively involved in, design, construction, operation, and modification of several of EERC's major pilot plant systems, including the 8- by 8-inch and 18- by 18-inch bubbling FBC systems. Mr. Hajicek will dedicate over 80 percent of his time to this project and will take the lead responsibility for Tasks 2, 3, 4, and 5.

Technical and operational personnel for this project will be drawn from the Center's existing staff. This staff is highly experienced with the design, construction, operation, and maintenance of pilot-scale combustion systems, including fluidized-bed combustors. The technical staff is experienced with the design and implementation of parametric test matrices designed to obtain maximum data with minimal testing. A fully staffed and equipped coal analysis laboratory is on site for responsive supply of all standard coal analyses. There are also highly trained personnel who have a

complete array of state-of-the-art analytical equipment available for any specialized analyses that would be useful for this project.

Additional information on the Center's programs, personnel, and facilities is available upon request.

7.0 QUALIFICATIONS OF APPLICANT

The Combustion and Environmental Systems Research Institute of EERC is currently engaged in a wide array of projects. The U.S. Department of Energy is the largest single client, and the Combustion and Environmental Systems Research Institute works with both the Morgantown and Pittsburgh Energy Technology Centers on projects ranging from basic studies of coal combustion chemistry and mineral matter transformations to studies of corrosion/erosion/deposition in fluidized-bed combustion and methods of controlling the gaseous and particulate emissions from coal combustion systems. Additionally, work is underway on emerging technologies using coal, including diesel engines and coal-fired gas turbines.

Although the majority of the current projects are being performed for the government, the Combustion and Environmental Systems Research Institute has been very successful in the transfer of knowledge to the private sector. Projects involving ash deposition have been completed for many companies including Houston Power and Light, Detroit Edison Co., and Northern States Power. The Combustion Systems Group has been working with Montana-Dakota Utilities and Northern States Power to provide information on fluidized-bed combustion for their newly commissioned FBCs. Studies of emission control issues have been an important part of the Environmental Systems Group when working with companies such as EPRI, Westinghouse, 3M, Owens-Corning, Montana-Dakota Utilities, and American Crystal Sugar. By enhancing the basic understanding of combustion-related processes, the Combustion and Environmental

Systems Research Institute has successfully solved problems specific to various segments of the private sector.

The EERC has been involved in an array of fluidized-bed combustion (FBC) projects for both governmental and private entities. A listing of specific FBC experience is given in Table 3.

TABLE 3. EERC FLUIDIZED-BED COMBUSTION EXPERIENCE

Project	Sponsor
Fluidized-Bed Combustion Testing of Iowa Bituminous Coal	Stanley Consultants/Iowa Energy Policy Council
Fluidized-Bed Combustion Test Support	Burns & Roe
Consultation on Testing of a North Dakota Lignite at B&W	Montana-Dakota Utilities
Petroleum Coke FBC Characterization	Northern States Power
Utilization of Agriculture Wastes as Stationary Power Source	Valmont Industries/USDA
AFBC Low-Rank Coal Characterization	Department of Energy
Evaluation of Corrosion and Erosion from AFBC of Low-Rank Coals	Department of Energy
Study of Agglomeration in Fluidized-Bed Combustion	Department of Energy
Development of Heat Transfer Equations in Fluidized-Bed Combustion	Department of Energy
Firing Low-Rank Coal/Water Slurry in a FBC	Department of Energy
Technology Transfer Report: Fluidized-Bed Combustion of Low-Rank Coals	Department of Energy
Fluidized-Bed Combustion Training Program	Institute of International Education
Test Burn of Pakistani Coal	Foster Wheeler Energy Development Corporation

8.0 BUDGET

The estimated cost of the proposed research program is $1,005,000 over a 27-month period. The estimated cost per task is presented in Table 2. The total cost of the program is being shared by 11 different companies. The Energy and Environmental Research Center has also provided $25,000 of internal funding toward the project. The North Dakota Lignite Research Council has funded part of this program as part of Round 1 and Round 2 solicitations. This request is for an additional share in Project CFB. An estimated summary by category is presented in Table 4.

TABLE 4. ITEMIZED BREAKDOWN OF YEARLY PROJECT CFB COSTS

	This Request	Total
Personnel	$18,115	$425,000
Operating Expenses	11,466	212,000
Equipment	5,334	190,000
Indirect Cost	15,085	178,000
Total Cost Per Share	$50,000	$1,005,000