DOE/PC/91162--T15

Project: " DEVELOPMENT & TESTING OF INDUSTRIAL SCALE, COAL FIRED COMBUSTION SYSTEM,PHASE 3"

Contract: DE-AC22-91PC91162

Contract Period of Performance: 9/30/91 to 9/30/97

Fifteenth Quarterly Technical Progress Report

Period Covered by Report: July 1,1995 to September 30,1995

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Date Submitted: October 12,1995

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1. SUMMARY

In the third quarter of calendar year 1995 work continued on task 5, "Site Demonstration", with emphasis on installation of the 20 MMBtu/hr combustor and auxiliary equipment at the Philadelphia test site. The task 5 effort involves testing the combustor over extended periods under conditions that fully simulate commercial operation and that meet the combustion and environmental specifications for this project. To meet this project objective within the current work scope requires 500 hours of testing. Operation beyond this period will depend on recovering the added costs by placing the steam production from the boiler to beneficial use. During the present quarterly reporting period, over 90% of the components needed to implement the initial 100 hours of testing under task 5 were installed at the test site. The only major remaining work at the end of this reporting period, before fuel fired operation can begin, is to complete the wiring of the new control system and to check the installed components. As installation of each sub-system has been completed, tests to verify the mechanical integrity and operational performance have been performed. A number of components were found to have been damaged in transfer from Williamsport and they were repaired or replaced. It is anticipated that the wiring and checkout of the controls will be completed by the middle of the the 4th quarter.

In the present installation substantial improvements and simplifications have been made to all sub-systems compared to the Williamsport facility. Also, major improvements have been made in the air cooled slagging combustor. The objective is to develop a facility that can be offered commercially at a capital and operating cost that is competitive with clean fuel power systems. For example, the original electric relay control system has been replaced by programmable logic controllers. Also, each of the auxiliary sub-systems, such as water, air, and fuels have been modularized for ease of assembly and maintenance. Both these items result in capital and operating cost reductions.

The following highlight the accomplishment of the present reporting period. Details are given in Section 3.

The installation of the combustor, boiler, pulverized coal storage, sorbent storage, and stack baghouse and ducting was completed in the previous reporting period. The focus of the present quarterly reporting period was on the auxiliary components and on the controls and diagnostics. As noted, a new feature of the present installation is the modularization of the auxiliary systems, namely, the gas and oil firing systems, the cooling water systems, the compressed air system, and combustion/cooling air systems. The installation of these systems was over 90% completed in the present quarter. The only remaining work is to complete the connection of the control wiring to the system operation control panel and to the control computer. Initial checkout of all these sub-systems were performed, including leak checks of all fuel, air, and water circuits, checkout of the electrically and pneumatically controlled components, such as valves. Several of the valves, gauges, and controller had to be refurbished due to wear or damage in transit from Williamsport.

Also as noted, the present emphasis is to develop a low capital and operating cost, coal fired combustion focused on the air cooled combustor. Accordingly, a great deal of effort has been devoted on the auxiliary components which are the major cost components in a steam generating power. For example, the internal electric power consumption has been reduced from 200 kW in Williamsport to an estimated 70 kW in the present facility. (This excludes raw coal preparation which was not performed at the Williamsport site.) This power reduction was accomplished from the operating experience in the Williamsport facility, and by evaluating alternatives to all elements of parasitic power. For example, in some of the air circuits that were previously operated with compressed air are now operated with fans and blowers, which sharply reduces the power consumption. However, in the checkout of the various components, it has been found that some of them have greater power consumption than anticipated from manufacturer's specifications. Accordingly, additional changes in operating procedure will be implemented to optimize power consumption.

Electric power to all components were installed and the operability of all the electrically operated components, such as fans, was verified. Much of the control circuitry was installed including the programmable logic control circuits were installed. Due to scheduling difficulties with two sub-contracts, the final connections to these circuits has been delayed to the beginning of the 4th quarter of this calendar year. To maintain installation schedule much of the control installation has being performed by Coal Tech's personnel. While this increased the time required, it has resulted in additional improvements and simplifications in the control circuitry..

Another major focus in the installation has been to minimize component and sub-system costs. By careful procurement and by using innovative component selection and sub-system integration, substantial cost reductions have been achieved. One aim of this effort has been to develop the specification to be used in future commercial plants based on the air cooled combustor. The results to date indicate that very substantial system simplifications and cost reductions in the auxiliary components can be achieved. The results to date confirm the prior conclusion from the task 4 system studies that coal power plants using this overall design can readily achieve total costs under $1000/kW in the size range up to 20 MW.

Also in this quarter, well over 50% of the refurbishment work on a novel, low cost coal pulverizer was completed. Also, the design of the raw coal storage system was reduced in capacity and it was further simplified. As a result, the cost and schedule to implement, of the raw coal processing system, which will be used for the final 400 hours of testing, has been further reduced. The coal mill will be tested with batch loads of coal, in the 4th quarter, and if the results are satisfactory, the rest of the system will be installed. Furthermore, this mill will be used in future commercial offerings of this combustion system.

It is planned to complete the controls system wiring early in the 4th quarter, to be followed by checkout of the propane pilot gas system, the oil heatup system, and initial coal firing. With the improvements introduced to date, the completion of the scheduled 500 hours of testing will require substantially less effort than was required for the same test period in the Williamsport combustor installation. Following the success of these tests, it is planned to offer this system on a commercial basis. Also, it is planned to continue testing, if revenue from the energy production of the facility can be achieved.

Figure 1 is a plot plan of the installation of all the planned equipment at the task 5 test site. Figure 2 is a photograph of the combustor and boiler installation at the test site that was taken recently, and it shows the current status of the installation. This should be compared with the photograph of this facility taken in May 1995 that was contained in the prior quarterly report to show recent progress.

2. PROJECT DESCRIPTION

2.1. Objectives

The primary objective of the present Phase 3 effort is to perform the final testing, at a 20 Mmbtu/hr commercial scale, of an air cooled, slagging coal combustor for application to industrial steam boilers and power plants. The focus of the test effort is on combustor durability, automatic control of the combustor's operation, and optimum environmental control of emissions inside the combustor. In connection with the latter, the goal is to achieve 0.4 lb/ MMBtu of SO_2 emissions, 0.2 lb./MMBtu of NO_x emissions, and 0.02 lb. particulates/MMBtu. To meet the particulate goal a baghouse will be used to augment the slag retention in the combustor. The NO_x emission goal will require a modest improvement over maximum reduction achieved to date in the combustor to a level of 0.26 lb./MMBtu. To reach the SO_2 emissions goal may require a combination of sorbent injection inside the combustor and sorbent injection inside the boiler, or stack.

The original plan was to meet the project objectives by a series of increasingly longer duration tests totaling up to 800 hours, with over 500 hours in the task 5 "Site Demonstration" effort. In the implementation of the first three project tasks, it was determined that this objective could met by daily cycling of the combustor in these three tasks, and by focusing the test effort on fuel flexibility and optimized combustion and environmental performance. Cycling without combustor refurbishment between cycles provides a more stringent test of combustor durability. In task 5, the steam output will be blown off. However, the option has been added to use the steam for process heat or steam turbine power generation if a means for generating revenue from this energy is developed during task 5. This last option will only be implemented after the completion of the required testing under the present project.

The final objective is to define suitable commercial power or steam generating systems to which the use of the air cooled combustor offers significant technical and economic benefits. In implementing this objective both simple steam generation and combined gas turbine-steam generation systems will be considered.

2.2. Technical Approach

2.2.1. Overview

The work of this Phase 3 project will be implemented on Coal Tech's patented, 20 MMBtu/hr, air cooled cyclone coal combustor that is installed on an oil designed, package boiler. The task 2 and task 3 testing were performed at a manufacturing plant in Williamsport, PA, where this combustor was installed in 1987. The task 5 tests will be implemented at a new site in Philadelphia, PA which was selected after the completion of the task 3 tests. The combustor has undergone development and demonstration testing since 1987. The primary fuel has been coal. Other tests, including combustion of refuse derived fuels and vitrification of fly ash, have been successfully performed.

The combustor's novel features are air cooling and internal control of SO_2, NO_x, and particulates. Air cooling, which regenerates the heat losses in the combustor, results in a higher efficiency and more compact combustor than similar water cooled combustors. Internal control of pollutants is accomplished by creating a high swirl in the combustor which traps most of the mineral matter injected in the combustor and converts it to a liquid slag that is removed from the floor of the combustor. SO_2 is controlled by injecting calcium oxide based sorbents into the combustor to react with sulfur emitted during combustion. The spent sorbent is dissolved in the slag and removed with it, thereby encapsulating the sulfur in slag. Part of the sorbent exits the combustor with the combustion products into the boiler where it can react with the sulfur. The spent sorbent either deposits in the boiler or it is removed in the stack particle scrubber. NO_x is controlled by staged, fuel rich combustion inside the combustor. Additional reductions are achievable by reburning in the boiler or by ammonia injection if the stack gases. Neither of the latter two procedures has been attempted in this project to date, but they may be required to meet the task 5 operating conditions at the site selected for this effort. Final combustion takes place in the boiler.

Excellent progress had been made prior to the start of the present project in meeting several of these combustor performance objectives. One of the most important objectives of this technology development effort is to demonstrate very high SO_2 reduction in the combustor. Prior to the start of the present Phase 3 project, the peak SO_2 reduction achieved with sorbent injection in the combustor had been 56%, (+/-) 5%. Of this amount a maximum of 11% of the total coal sulfur was trapped in the slag. On the other hand, up to 81% SO_2 reduction has been measured with sorbent injection in the boiler immediately downstream of the combustor. Tests in the past several years have revealed the critical role played by optimum operating conditions in the SO_2 reduction process. Specifically, combustor operation must be automatically controlled, and solids feed and air-solids mixing in the combustor must be optimized. Progress in both areas has been accomplished in the past 5 years by using a microcomputer to control the combustion process and by testing various methods of feeding and mixing the coal and sorbents. In the summer of 1992, tests performed in a prior project indicated that in excess of 90% SO_2 reduction could be achieved by sorbent injection in the combustor. However, to date this result has not been duplicated, in part due to focus on other areas of combustor testing. In general, 70% SO_2 reduction has consistently obtained in tasks 2 and 3 at Ca/S ratios between 3 and 4.

Combustor durability is an essential requirement for commercial utility of the combustor. Due to the aggressive nature of the combustion process and the need to utilize refractory materials inside the combustor to withstand the 3000F gas temperatures, durability has been one of the key challenges in the development process. Here also the use of computer control has been the means whereby this problem is being solved. Since introduction of computer control four years ago, the need for frequent refractory liner patching inside the combustor has been sharply reduced. The durability issue can be addressed by accumulating running time in daily cyclic operation without combustor refurbishment between runs. This approach has been used in the latter task 2 and task 3 effort. All tests between May 1 and December 2, 1993, consisting of 26 hours of operation in task 2 and 185 hours in task 3, have been performed without significant internal combustor refurbishment.

The final project objective of placing the combustor in a viable industrial steam or power generating system was accomplished by detailed engineering analysis on the use of the combustor in one or more steam generating cycles. This effort included an assessment of the requirements for commercializing the combustor for several industrial application. To assure commercialization of this technology, the final project task is being implemented in a system that duplicates a commercial prototype power plant utilizing the air cooled coal combustor technology.

2.2.2. Task Description

Task 1: Design, Fabricate, and Integrate Components

This task consists of components design, component fabrications, and components integration, and shakedown tests. The 20 MMBtu/hr combustor will be modified to allow safe and environmentally compliant operation for periods of up to 100 hours. This task is complete.

Task 2: Preliminary Systems Tests

The modified combustor system will undergo a series of one day parametric tests of total duration of up to 100 hours to validate the design changes introduced in task 1, and to accomplish the project objectives and goals. This task is complete.

Task 3. Proof of Concept Tests

The durability of the combustor will be determined in a series of tests of between 50 and 100 hours of accumulated operation with no combustor refurbishment between tests. The total test period will be up to 200 hours. This task is complete.

Task 4. Economic Evaluation & Commercialization Plan

The economics of one or at most two different industrial scale steam based cycles using the combustor will be evaluated. A commercialization plan will be developed for marketing the combustor in an industrial environment both in the US and overseas. This task is complete.

Task 5. Conduct Site Demonstration

This task will be the final test activity in the project. Its objective will be to demonstrate the durability and hence the commercial readiness of the combustor for its intended industrial application(s). The effort will consist of two sub-tasks. In the first one any changes required as a result of prior tests will be made to the combustor. In the second one, a series of tests, each of up to 100 hours of continuous coal fired operation will be performed, with a total test time of 500 hours. This task is in the installation phase.

Task 6. Decommissioning Test Facility

The test facility will be removed from the boiler installation and disposed in accordance with required regulations.

3. PROJECT STATUS.

3.1. Task 5. Site Demonstration

The installation of the combustor-boiler facility continued during the past quarter. The present facility is the commercial prototype for this power system using the slagging combustor technology. As a result, considerable emphasis is being placed on assuring that all components and sub-systems are optimized with respect to performance and economics. Innovations and improvements have been incorporated as the work progressed. Many of these became apparent only as specific components were installed. In some cases, the components or sub-systems were modified after installation when further improvements were uncovered.

For example, the 100 hp fan that had been used in the Williamsport combustor facility as the primary source of combustion cooling and combustion air had been installed but not electrically connected to the power lines. It was then determined that its functions could be replaced with a 50 hp fan. This change was made possible after analysis of the Williamsport combustor test data showed that the combustor air cooling could be re-arranged to allow operation at a substantially lower air pressure.

Another example, was the arrangement of the combustor water cooling circuits which were modified several times during the installation to reduce the number of circuits and to incorporate contingencies in the event of cutoff of cooling water. The water cooling circuits have been re-arranged to eliminate any possibility of discharge of chemical species into the water discharge to the sanitary drain.

This procedure was followed in the installation of all components and sub-systems. The major improvements are the modularization of all the auxiliary sub-systems, which greatly simplifies their maintenance during tests and between tests. It also allows disassembly of these sub-systems as units during facility removal. As a result, a commercial plant based on the present design can be factory assembled in modules for shipment to the customer's power plant site.

Due to the use of this installation procedure, the work has been accomplished primarily with Coal Tech's engineering staff, as opposed to extensive use of sub-contract installation technicians, as had been the case in Williamsport. This has required more time to complete the installation. On the other hand, it has provided an added benefit of fully acquainting the Coal Tech test staff with all aspects of the facility. This familiarity of test personnel with all aspects of the facility should greatly reduce the length of shutdowns during a test that are caused by equipment malfunction.

In the following sub-sections, the progress made in the past quarter will be summarized, while noting some of the improvements that have been made. The discussion will be in general terms because several aspects involve potentially proprietary and patentable designs and procedures.

3.1.1. Installation of Test Equipment

Combustor Installation: The combustor was attached to the boiler in late June after the installation of the refractory inside the combustor. After the attachment, additional refractory was installed to connect the exit nozzle to the boiler refractory section. During the design of the air ducting to the combustor, it was determined that a fabrication error required rewelding of one of the air inlet ducts to the combustor. This problem was corrected in only several days because the present combustor design allows rapid removal of the combustor from the boiler. The combustor refractory installation was completed in early August. The final curing of the refractory will be done during the initial firing of the combustor with propane and oil.

Auxiliary Components:..

Boiler: Prior to completion of the boiler installation, the Philadelphia Region boiler inspector for the State of PA visited the site to review the compliance status of the boiler. Since it is planned to initially operate in the steam blowoff mode at 15 psig, a State inspection is not required. However, it is planned to have the insurance carrier's inspector review the boiler installation. The only issue that raised by the Inspector concerns the need for a water drain between the two steam valves on top of the drum. This can be installed by drilling a small opening in the downstream of the two steam outlet valves. However, we believe that this is not necessary for operation in the blowoff mode because the condition for which this drain is required, namely to eliminate accumulation of condensate between the valves, cannot occur in blowoff steam mode of operation.

The second boiler installation item is the boiler blowdown tank. The State inspector stated that an ASME blowdown tank is not necessary for operation at low pressure of 15 psig. Quotes for an ASME tank were found to be high. Therefore, a non-ASME certified blowdown tank was designed and fabricated by Coal Tech personnel. The cost of the tank was substantially less than a purchased tank. The blowdown tank will be connected to blowdown piping which was installed at the lower boiler drum. To comply with the City Plumbing and Sanitary Discharge Codes, the boiler blowdown water will be mixed in the blowdown tank with the combustor cooling water to maintain a maximum discharge temperature of 140 F to the sewers. The discharge temperature will be measured with a stem thermometer as well as a thermocouple that will continuously record this temperature.

The soot blowing system for the boiler tubes was reassembled. It was necessary to refurbish it as several parts were either missing of defective. Also to provide greater operational flexibility, compressed air soot blowing was added to the steam soot blowing. An automated valve system used previously for another application was installed to control the boiler feedwater.

Work began on the reinstallation of the boiler controls. This effort is within 1 to 2 labor days of completion.

A key new element in the boiler control is to maintain the combustion gas pressure in the boiler at a slightly negative draft of 1 to 2 inches water pressure. In Williamsport this was readily maintained when operating with oil and gas by keeping the 50 ft high original stack open. When operating on coal with the scrubber, a damper was installed on the new stack outlet from the induced draft scrubber fan. It was operated by a pressure limit switch that activated an electric motor on the fan outlet damper. This proved unsatisfactory as the damper could not follow the constant on-off signals from the pressure switch. Also, exposure to the weather caused the damper links to rust and jam. As a result, the damper was removed and operation on coal was only initiated at about 50% of full boiler thermal load. At this condition, the boiler retained an acceptable negative draft even in the absence of the stack damper.

This situation will not exist in the present boiler arrangement because there is only one stack, namely at the outlet of the induced draft fan. Consequently, a pneumatic controller, operated by a continuously variable electric signal will be used. The electric input signal will be obtained by a pressure transducer connected to the main furnace chamber in the boiler. This installation is over 90% complete

Combustion Air Ducting: The combustor air ducting used in Williamsport was removed and shipped to Philadelphia. However, after due consideration, it was decided to eliminate almost the entire system due to its great weight and limited flexibility of operation. In its place a lighter weight, air ducting to the combustor was designed, fabricated, and installed on the combustor. During the installation this design was further simplified, while maintaining flexibility to allow rapid disassembly and maintenance of the combustor.

As previously reported, the new air cooling design has eliminated the large combustion air fan, as a result of which the power consumption will re reduced from 130 kW to 70 kW. The 70 kW power consumption compares to 200 kW in Williamsport.

Power: Most of the power lines needed to operate all the equipment were installed, including power for the coal mill. This includes circuits to power the air compressors (which in Williamsport were driven by a diesel engine), fans, blowers, the coal mill, the stack fan, sorbent feeders, and various smaller items, such as water pumps, controls, computers, etc. Much of this work was performed by a sub-contractor, with the balance by Coal Tech. Here also, a number of simplifications were introduced to improve the reliability of the equipment as well as simplify the removal of the equipment at the end of the test effort.

During the task 5 installation design, it had been assumed that the power level would remain the same as in Williamsport, namely 200 kW. To this would be added the power for the air compressor, which would now be electrically powered. To this would be added about 30 kW for operation of the raw coal storage and pulverization system. Due to the factor of four higher power cost in Philadelphia, it was planned to acquire a diesel electric generator. A permit to allow installation of a diesel electric generator was obtained from the Philadelphia Air Quality Management Board. This required utilization of the combustor to control soot and NOx emissions, which are subject to stringent regulation in Philadelphia. Also, the present building is wired only for 130 kW, and an additional power line, obtainable only at high cost from the landlord, would have been required to use the power from the local utility.

It was these two very high cost alternatives that forced a re-examination of the entire issue of on-site power consumption. While the largest component of power savings was from a reduction in the fan power, substantial additional savings were achieved by carefully examining other power requirements for blowers, compressors, pumps, etc. This led to a reduction of power requirements to 70 kW, without the raw coal system, and 100 kW with the raw coal system. This is well within the installed power line capacity of 130 kW in the present building. Therefore, the diesel generator acquisition was eliminated. This has significant implications for future commercial plants. The 100 kW in plant power is only 20% of the 500 kW that can be generated with an atmospheric backpressure, single stage turbine in this boiler, and 10% of the 1 MW can be obtained with a high vacuum condensing turbine. In a higher pressure boiler, the in plant power consumption would decrease further. Since air handling is the major in plant power element, this new low power configuration results in an important additional advantage of the air cooled slagging combustor, over the more complex water cooled combustor.

Noise: With the removal of the 100 hp fan, it had been assumed that the noise level would decrease to acceptable values. However, initial startup of the smaller primary air fan revealed that its noise level was still too high. Also, the pneumatic coal feed blower operates at a high noise level even with silencers. The latter blower could be replaced with a quiet blower that has a lower pressure rating. However, until the present coal feed system is tested, it was judged prudent to acquire extra pressure capacity. Since Coal Tech is assembling many sub-systems in house, it was decided to acquire the coal feed blower in components and use a redundant motor to power it. This will result in a projected costs saving of between 25% and 50% over the purchase of an assembled package. Depending on this whether this blower is placed inside the building or in the adjacent alley, a decision will be made on either enclosing this equipment in a sound silencing room, or adding silencers to the fan.

Compressed Air & High Pressure Blower: In Williamsport, all air not provided by the combustion fans, was provided by a high pressure compressor. In the present installation, a high pressure blower will be used for pneumatic transport, while a high pressure compressor will be used for controls and items such as air atomization of the oil burner.

Considerable effort is being expended on optimizing the various air flows. This consists of the fans for combustion, cooling, and stack gas, the blower for pneumatic conveying of solids, the continuous intermediate compressed air supply, and the intermittent high pressure air supply for controls. The fans are the same as in the prior facility. They are now installed and operational. A blower and small instrument air compressors were purchased and installed. In addition, it is planned to acquire a larger compressor for the balance of the higher pressure air needs. This unit will also assembled in house from components. In view of the uncertainty in some of the air pressure, a rented diesel compressor may be used in initial checkout tests.

The small, intermittent air compressor will be used for control purposes, and it was used to checkout the operation of these components. For example, it was observed that one of the pneumatic valve operators developed a minor leak in transit from Williamsport, and it has been repaired. Also, the air pressure requirements of several compressed air driven components was accurately measured in order to further reduce air consumption.

In view of the low cost and low power consumption of the high pressure coal feed blower, it was decided to proceed immediately with its acquisition rather than perform a series of tests with limestone using a rented compressor to accurately determine the air pressure requirements. This purchased unit has sufficient capacity to duplicate the operating conditions used in Williamsport.

The small compressor was used to perform pressure leak tests on the propane, oil, and compressed air lines, and numerous joint leaks were found and repaired, especially in the high pressure piping. In Williamsport, an oversize rented compressor was used for all air lines except the combustion air lines. Therefore, no attention was paid to minor leaks in compressed air lines, nor was the compressed air consumption monitored.

In the present system, major emphasis is being placed on minimizing plant parasitic power. Therefore, air consumption tests were initiated last month on various compressed air lines such as the combustion air valve controllers, and the baghouse cleaning system. It was determined that several of these systems can operate at much lower pressure and air consumption than previously used. On the other hand, other components were found to have higher air consumption rates. All these results are being incorporated in the final sizing of the air compressor. Also, the mode of operation will be adjusted to minimize the air consumption of these components.

Oil System: After ignition on gas, (in the present case propane), No.2 oil firing commences for pre-heating the combustor. In Williamsport, the combustor was installed in a boilerhouse that was equipped with a large underground oil tank and a oil delivery system. In the present installation, the entire oil system had to be installed. The original plan to install a 1000 gallon No.2 oil tank adjacent to the building was abandoned due to its very high cost. The tank requires a special City license. It must be installed on an elevated platform because the site is in a flood plain. Doubly contained oil piping is needed to eliminate the possibility of leaks, and a long pipe run would have been required. Instead on this option, a pair of domestic oil tank with 550 gallon capacity were purchased and installed inside the building. These tanks require no special City license. This capacity was found to be adequate after evaluation of the oil consumption used in Williamsport. A small oil pump and piping to the combustor were also installed and leak checked. The cost of the entire oil installation is about 10% of the cost of the originally planned outdoor installation.

To eliminate oil spills, in the remote event of a tank leak, a 275 gallon retention box formed from sheet metal left over from a previous project . Although the in-house labor cost to fabricate this retention box was double that of the two oil tanks, it was considerable less than the cost of a 550 gallon tank with a retention dike, and it was considered a necessary step to eliminate the possibility of oil leaks from the tanks.

Controls: The final item required before combustion operation begins is the wiring of the controls. Most of the combustor operation had been converted to computer control in Williamsport. However, several key components, such as the gas fuel control system, the fan start-shutdown system, the flame safety system, the boiler controls, and several other control elements remained under manual control using relays. The original plan last year had been to reinstall this system. However, our computer expert suggested that conversion of this relay control system to programmable control logic (PLC) circuits would simplify the control function, increase reliability substantially, and reduce cost in future commercial systems.

Accordingly, beginning early in the second quarter of this year, this conversion process was initiated using a part time individual for this purpose. Unfortunately, this work stopped in early August due to illness. The backup person who was familiar with the operation of this system in Williamsport was also not available. Therefore, Coal Tech personnel were used to complete this work with input from these individuals. To date, the controls to the coal and sorbent feed systems, the fan motor systems, most of the flame safety and gas firing system, and the water and air flow, pressure, and temperature systems are installed. The balance of the controls including programming the PLC's remains to be completed. This requires only a few weeks work and its implementation will depend of the availability of the above personnel. It is anticipated that this work will be completed early in the fourth quarter.

Two important benefits of using Coal Tech personnel for this purpose is that further improvements were uncovered during the installation, and more importantly, Coal Tech personnel are becoming fully acquainted with all aspects of the control system. This will eliminate reliance on outside contractors during the operation of the combustor which will not only reduce operating costs, but also reduce down time due to control circuit malfunctions.

Coal Tech personnel connected the control wiring from the various operating modules, namely water, gas, oil, to circuits in the control cabinet. The UV and IR flame detectors were installed and connected to the control cabinet. An example of savings attained with in house personnel occurred during installation of the IR detector. A 40 foot long control wire length was specified to connect the IR detector on the combustor to the control cabinet. The IR detector supplier charges **18%!** of the original cost of the entire system for this 40 ft wire. The wire supplied with the detector was only 12 ft long and it had been lengthened to 30 feet for use in the Williamsport installation. In the move it had been misplaced, but after a search the wire was found and installed by rerouting from the original routing. .

The manual pneumatic controls for the various valves used to control the combustion air were connected and tested. It was noted that one valve control cylinder was damaged during installation and it was repaired. Another valve operated improperly, and it is being repaired. Also, a high compressed air consumption was noted, especially in one valve. Since compressed air is an energy loss, considerable attention will be devoted to minimizing this air loss.

The pitot tubes used to measure the pressure and flow in the various combustion air ducts were installed. They are connected to the gauges and pressure transducer used for visual and computer recording and for control. The pneumatic data acquisition and control circuits are being rearranged to reflect the current operating range. This is being accomplished by using gauges and instruments originally used for different functions in Williamsport.

Slag Tank Water System: A modified and greatly simplified slag tank cooling system designed and installed. The slag removal conveyor had been a source of major operational breakdowns in Williamsport. A simpler and more reliable slag conveyor was designed by modifying the original slag conveyor. All these changes reflect the experience of the test work in Williamsport, and the present system is far simpler to maintain than the one used in Williamsport.

To prevent any discharge of slag tank cooling water into the sanitary drain, a closed loop heat exchanger system was installed. It includes a system to remove slag grit to prevent plugging of the circulating pump. The controls for the slag conveyor system were reinstalled.

Coal Mill: Work began on refurbishing a leased, low cost coal mill that will be used for the on site coal pulverization. The refurbishment cost is about 10% of the cost of a similar rated new ball mill, and about one-third the cost of purchasing and refurbishing a used ball mill. If this mill proves its durability, it can be marketed at a much lower price that conventional impact and ball mills. This step is therefore another key element in our objective of developing a low cost coal fired power plant. The other raw coal equipment, including the storage bin, conveyor belt, and coal drying equipment will be procured after the completion of tests on this refurbished mill. It is anticipated that the mill will be operational by the latter part of October and initial checkout tests will be performed with limestone and coal.

Figure 1 shows a plan view drawing of the entire facility installation, including the coal processing system. Figure 2 shows photographs of the facility that were taken recently. They should be compared with those taken in May 1995, which are contained in the previous quarterly report to indicate the progress made since May.

4. Effort of the Next Quarter

The completion of installation of the balance of the equipment necessary for the first 100 hours of operation will take place in the next quarter. This involves a schedule slippage of several additional months. One reason has been the non-availability of several key sub-contract personnel. Another reason has been the need to optimize the available resources. The primary reason has been to assure that a key project objective, namely is to develop a low capital cost power system, is met. Therefore, as new lower cost options were uncovered in the installation task, they were introduced, even if it required removal of some components used in Williamsport. Examples include the reduction in power requirements, the simplification of the air ducting and coal and sorbent feed, and the installation of the combustor in a manner that allows its rapid removal. This effort confirms that the present combustor boiler technology will be a low cost solid fuel fired system that will compete on capital cost with clean fuel power systems.

Following completion of the control wiring, checkout tests with propane firing, oil firing, and then off site pulverized coal firing will commence during the second half of the present quarter.

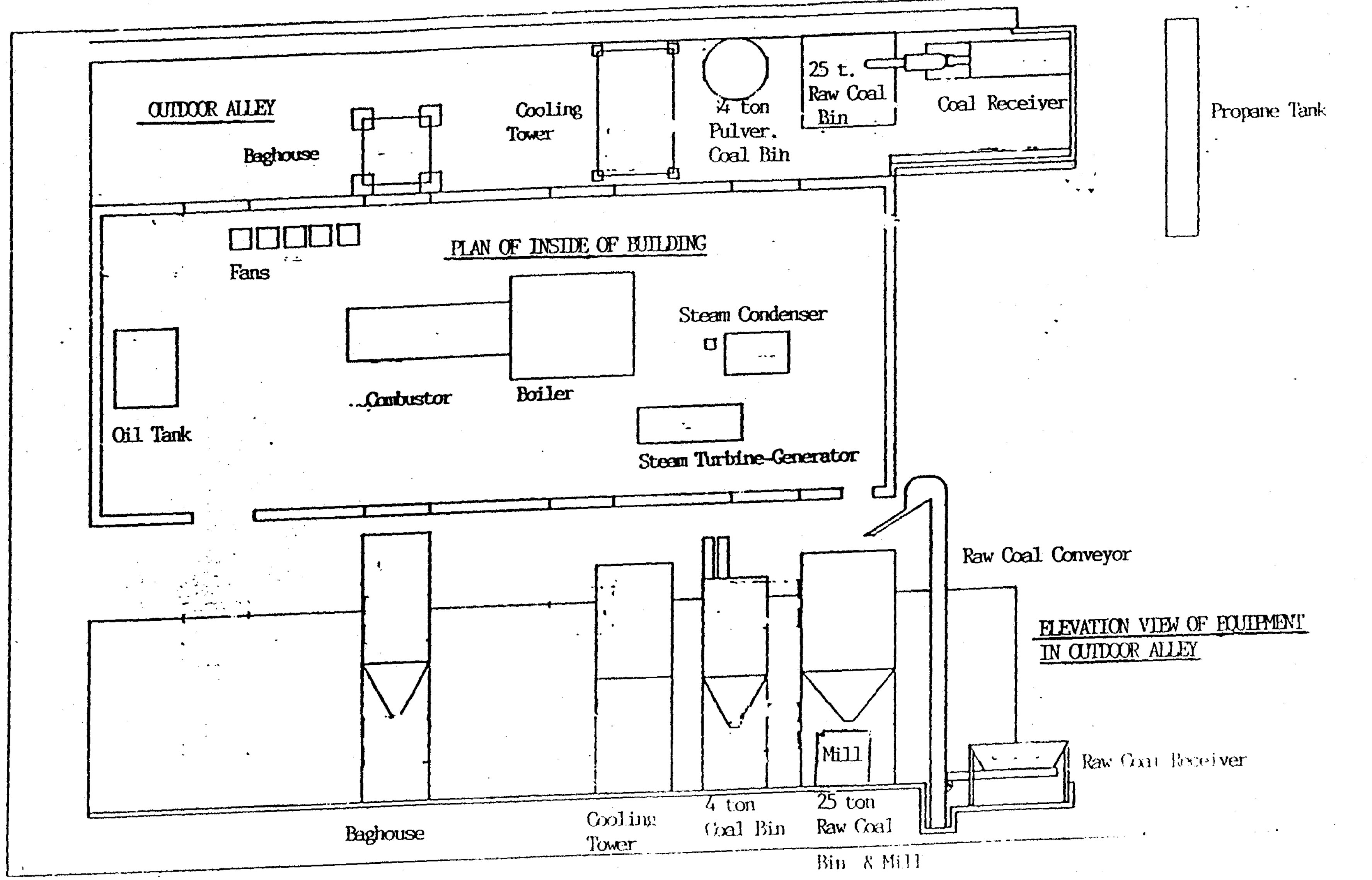

Figure 1: Plot Plan of the 20 MMBtu/hr Combustor-Boiler Task 5 Test Site in Philadelphia.

Figure 2: Recent Photographs of the 20 MMBtu/hr Combustor-Boiler Installation