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DEVELOPMENT AND TESTING OF A COMMERCIAL-SCALE COAL-FIRED COMBUSTION SYSTEM – PHASE III

Quarterly Technical Progress Report No. 11
Report Period: April 1, 1993 to June 30, 1993

By A.F. Litka and R.W. Breault

We have no objection from a patent standpoint to the publication or dissemination of this material.

Mark Dvorscak 1-22-96

Mark Dvorscak Date
Intellectual Property Law Dept.
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Tecogen
A division of Thermo Power Corporation, a Thermo Electron company
45 First Avenue
P.O. Box 8995
Waltham, Massachusetts 02254-8995

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Prepared for
PETC Project Manager: Mr. Douglas Gyorke
Pittsburgh Energy Technology Center
U.S. Department of Energy
P.O. Box 10940
Pittsburgh, Pennsylvania 15236-0940

Prepared by
Tecogen
A division of Thermo Power Corporation, a Thermo Electron company
45 First Avenue
P.O. Box 8995
Waltham, Massachusetts 02254-8995

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1. INTRODUCTION

Coal is the most plentiful energy resource in the United States, and in 1987 it provided approximately one third of the quads of total energy consumed in the United States. Its use, however, has been largely restricted to utility power generation since World War II for environmental and economic reasons.

Within the commercial sector, oil and natural gas are the predominant fuels used to meet the space-heating needs of schools, office buildings, apartment complexes, and other similar structures. In general, these buildings require firing rates of 1 to 10 million Btu/hr. The objective of this program is to demonstrate the technical and economic viability of a coal-fired combustion system for this sector.

The development program includes all aspects of the process, from fuel selection and preparation to pollution control and waste disposal. In attempting to restore coal to small users such as residential and commercial space heating, it is important to recognize that fuel form is an important consideration because of its impact on handling and emissions. Ease of handling is an important criterion at the small sizes since complex equipment will add greatly to the overall system costs. Furthermore, manpower is not available to perform manual functions or keep complex equipment working. Emission levels, if not currently regulated, can be expected to be regulated at low levels in the future. The levels considered acceptable will be reduced over time, following the current environmental trends. Preparation and use of a coal-water slurry (CWS) fuel can aid in meeting these criteria. CWS use eliminates the need for dry pulverized coal with its attendant handling and dusting problems as well as its explosive potential. In addition, CWS is amenable to coal washing since coal cleaning technologies are generally water-based processes requiring fine grinding of the coal. For these reasons, the program objective will be met through the development of a CWS-fired system.

Although the CWS fuel in commercial practice will be manufactured by coal companies or fuel suppliers at regional facilities and transported to the user much as is done today with oil, the program includes the construction of a slurry production facility. In this way, all aspects of the fuel's use – from coal selection to combustion properties – can be evaluated and an economic evaluation of the process can be carried out.

The commercial-scale CWS-fired space heating system is a scale-up of a CWS-fired residential warm-air heating system developed by Tecogen under contract to the Department of Energy (DOE), Pittsburgh Energy Technology Center. This system included a patented nonslagging combustor known as IRIS, for Inertial Reactor with Internal Separation. The combustor concept employs centrifugal forces combined with a staged combustion process to achieve high carbon conversion efficiencies and low nitrogen oxides generation. Along with the necessary fuel storage and delivery, heat recovery, and control equipment, the system includes pollution control devices to meet targeted values of SO_2 and particulate emissions. In general, the system is designed to match the reliability, safety, turndown, and ignition performance of gas or oil-fired systems. Table 1.1 summarizes the performance goals of the system. Figure 1.1 is a process flow diagram for the system.

The successful development and future marketability of the heating system require a strong, dedicated team with expertise in a broad range of areas including CWS preparation, coal combustion, pollution control, component manufacture, and

TABLE 1.1

PERFORMANCE GOALS

• Thermal Input	– 4 million Btu/hr
• Thermal Efficiency	– >80%
• Combustion Efficiency	– >99%
• Emissions	– 1.2 lb SO_2/MMBtu 0.3 lb NO_x/MMBtu 0.03 lb Part./MMBtu
• Turndown	– 3:1
• Ignition	– Fully automatic startup with system purge and ignition verification
• Reliability/Safety	– Comparable to oil-fired commercial boilers
• Ash Removal	– Dust free and automatic or semi-automatic
• Routine Maintenance	– Less than one manhour per day and an additional two manhours per week
• Service Life	– >20 years

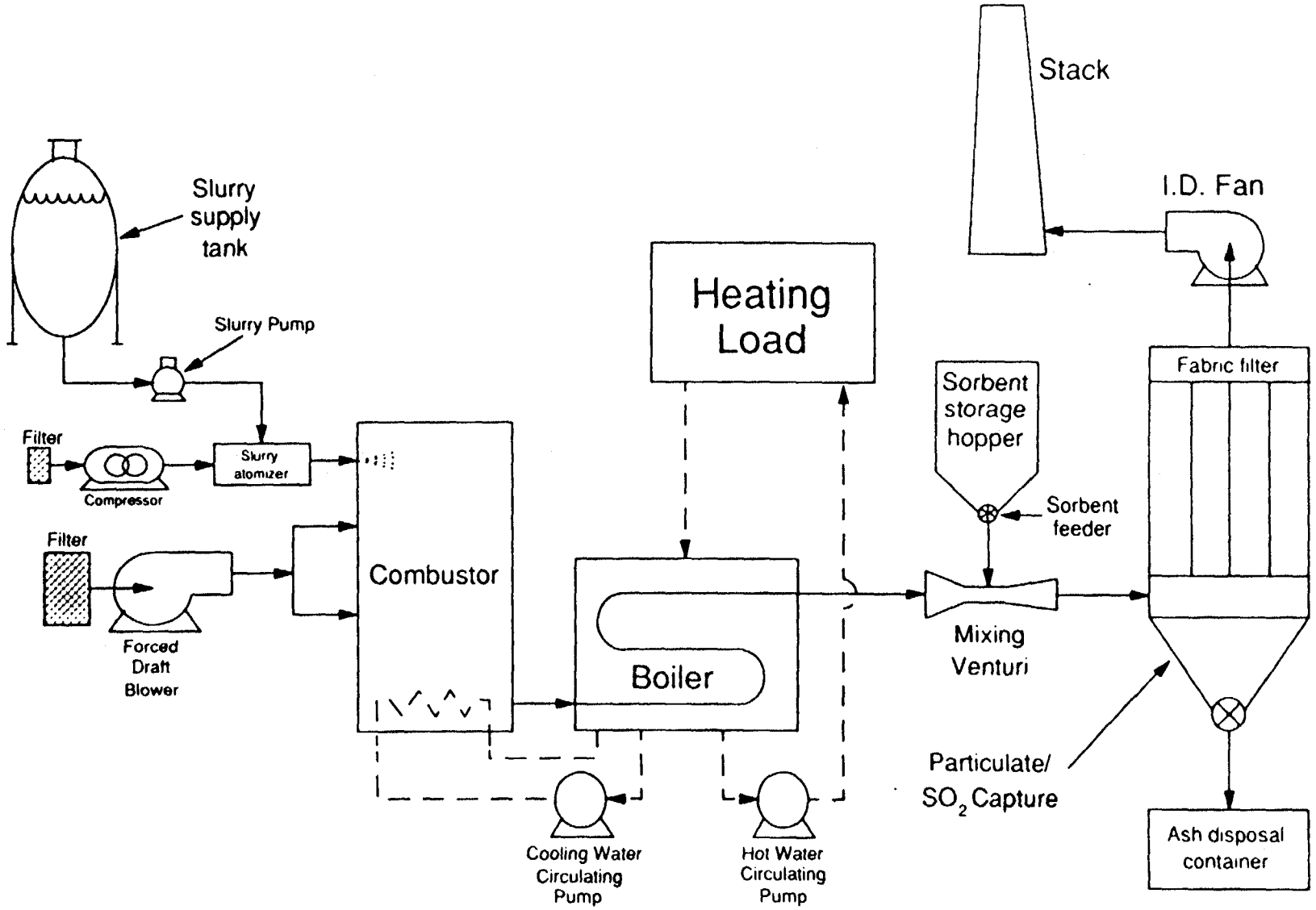

Figure 1.1 Process Flow Diagram

systems integration. Such a team has been assembled and includes the following organizations: Tecogen, Donlee Technologies, AMAX Coal, and Southern Illinois University.

Tecogen is the prime contractor and is responsible for overall program management, combustor development, and integration of the subsystem components and installation of the system at the field test site. AMAX has extensive experience in CWS preparation and serves as the principal coal supplier. Donlee Technologies is responsible for the boiler/heat exchanger design and manufacture. Donlee has over 70 years experience in the commercial boiler business and is a potential commercializer of the technology. Southern Illinois University (SIU) is the host for the field test portion of the program. The heating system will provide space heating at the SIU Coal Research Center.

The development program has been divided into three stages covering a time span of 39 months. The first stage of the program which covered 16 months focused on component design and manufacture. Once the major components were manufactured, system integration was completed and initial system tests conducted. These tests verified the design and operation of the system components as well as provided a data base for setpoints, process variables, and performance for subsequent proof-of-concept testing.

The second stage of the program covered eight months and focused on evaluating the overall performance of the system through Proof-of-Concept Testing. The testing was of sufficient duration to simulate a commercial application with individual tests of up to 48 hours in duration. Combustion and thermal efficiencies; tendencies to slag, foul, erode and corrode, and gaseous and particulate emissions were evaluated.

The final stage of the program which is currently underway will involve integration of the system in an actual installation and operation of the system over the course of a heating season. This demonstration stage is scheduled to cover an 18 month period. Figure 1.2 gives the work breakdown structure for the overall program.

This report documents the work carried out in the eleventh quarter of the program. During this period, installation of the coal water slurry fired space heating system and slurry production system was initiated at the Illinois Coal Development Park in Carterville, Illinois.

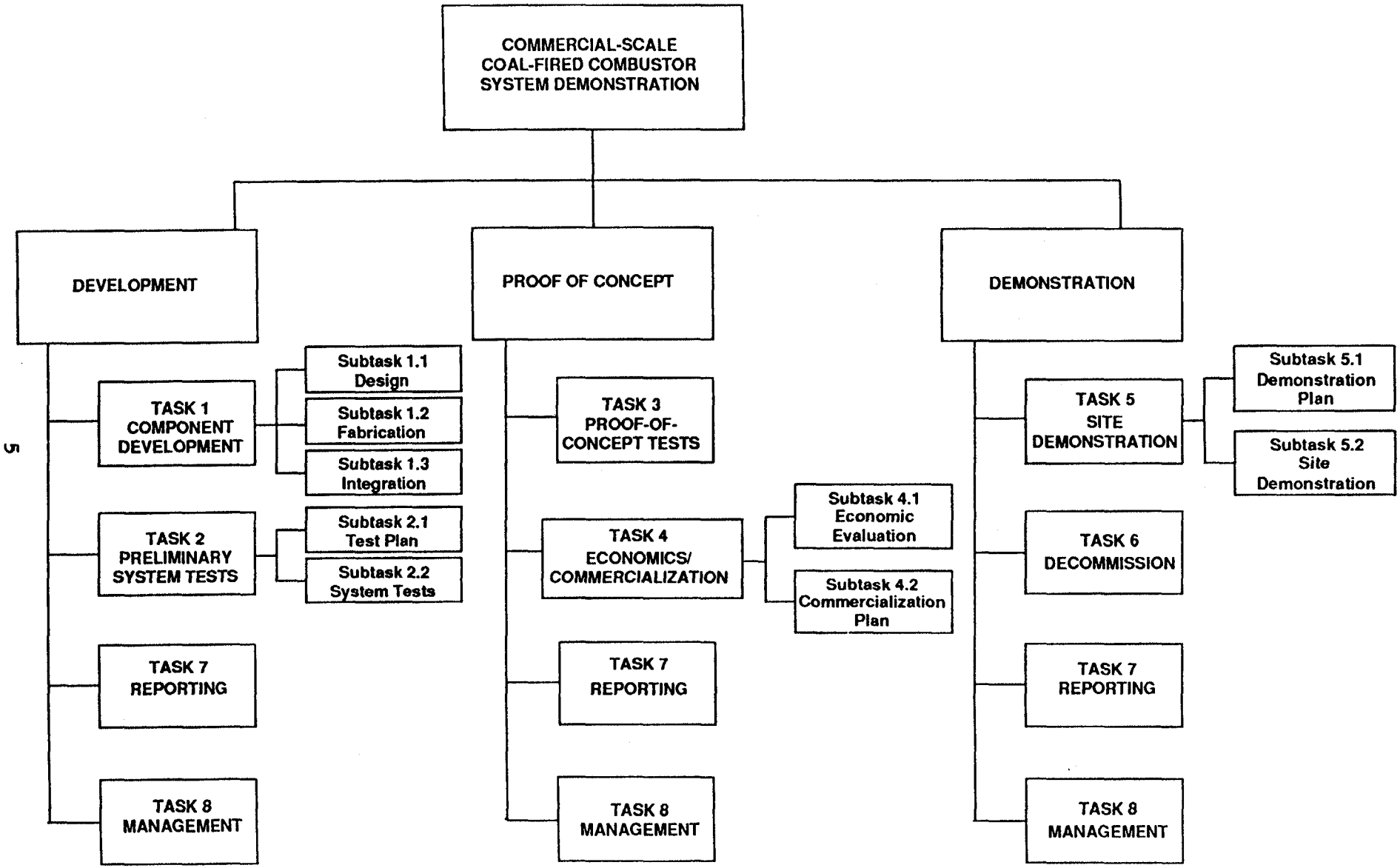

Figure 1.2 Work Breakdown Structure for Entire Project

2. PROJECT STATUS

During the eleventh quarter of this program, installation of the space heating system and slurry production facility at the demonstration site was initiated. The host site for the commercial demonstration wherein the equipment will be operated for approximately 1000 hours over the course of the next heating season is the High Bay Building at the Illinois Coal Development Park in Carterville, Illinois. The High Bay Building is a multi-use facility housing classrooms, laboratories, and offices.

2.1 SLURRY PRODUCTION FACILITY INSTALLATION

The bulk of the slurry production facility installation was completed. The major system components were assembled and positioned, and piping and wiring interconnections between the grinding stand and mixing stand were made. As can be seen in Figure 2.1, the coal grinding stand was placed outside the building to minimize noise and fugitive dust emissions inside the High Bay Building. Figure 2.2 shows the mixing stand along with the slurry storage tanks located adjacent to the space heating system. Four 1,000 gallon storage tanks have been provided to allow for extended system operation as well as provide flexibility in slurry formulation and parent coal selection.

2.2 SPACE HEATING SYSTEM INSTALLATION

Refurbishment and packaging of the space heating system equipment was completed at Tecogen's Waltham, Massachusetts facilities and the equipment shipped to the host site. DOE approval of an installation subcontract was obtained and installation of the equipment at the host site was initiated by Clayco Construction.

The major system components were placed in position and secured, and piping installation was initiated. Figure 2.3 shows the combustor and boiler modules in position. The combustor/boiler modules are located in the high bay area of the building in a convenient location for operation and maintenance of the equipment. Figure 2.4 shows the externally located equipment in position. The baghouse, air compressor, dump radiator, and fuel oil tank are all located on an equipment pad on the east side of the building.

The installation of the main piping runs was completed including the exhaust duct between the boiler and baghouse, the high bay area hot water circulating system, and unit heaters. All electrical work was completed including installation of control panels and conduit, and point-to-point wiring of motors and instrumentation. Figure 2.5 shows the position of the main control panel.

The remaining auxiliary system piping installation will be completed during the first part of the next reporting period when shakedown testing will be initiated.

Figure 2.1 Slurry Production Facility Grinding Equipment

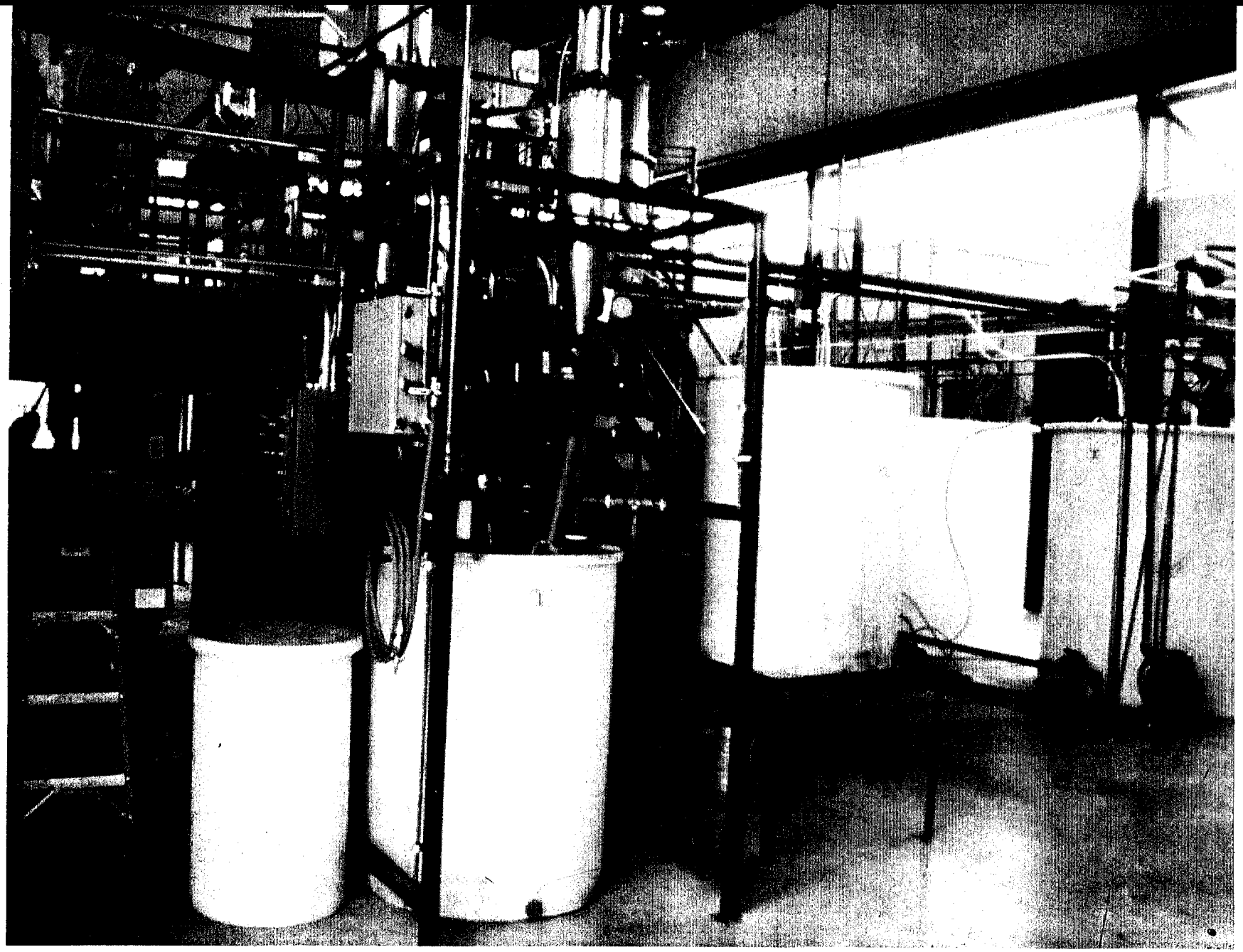

Figure 2.2 Slurry Production Facility Mixing Equipment

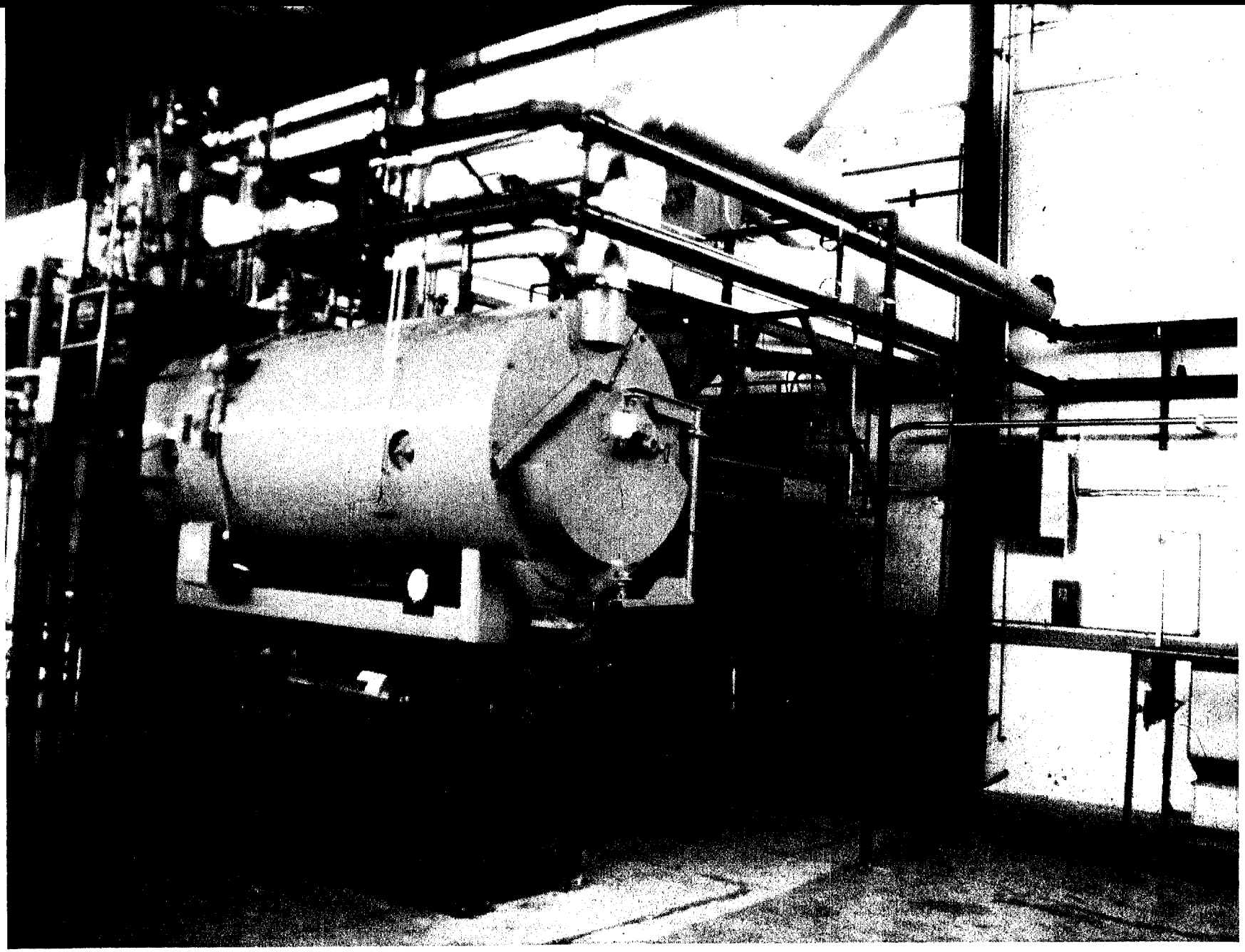

Figure 2.3 Space Heating System Combustor and Boiler Modules

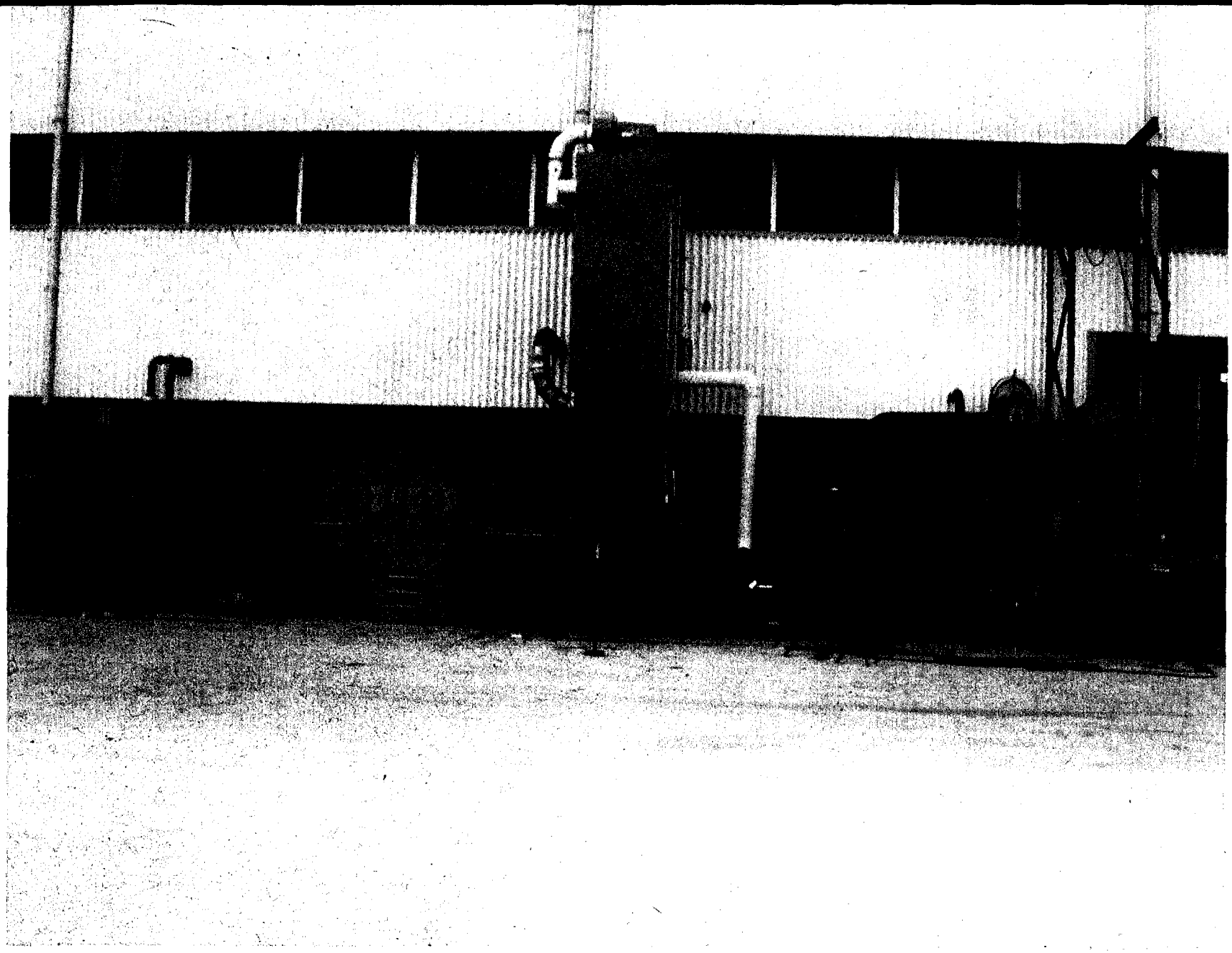

Figure 2.4 Externally Located Auxiliary Equipment

Figure 2.5 Operator Control Station

3. PLANNED ACTIVITIES

During the next quarter, installation of the slurry production facility and space heating system will be completed and shakedown testing will be initiated. Slurry production will be initiated to provide slurry for the shakedown testing and the upcoming heating season operation.

4. SUMMARY

During the past quarter, installation of the slurry production facility and coal water slurry fired space heating system at the Illinois Coal Development Park's High Bay Building was initiated. Installation is approximately 75% complete.