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Laboratory
Research Triangle Park NC 27711

Technology Transfer

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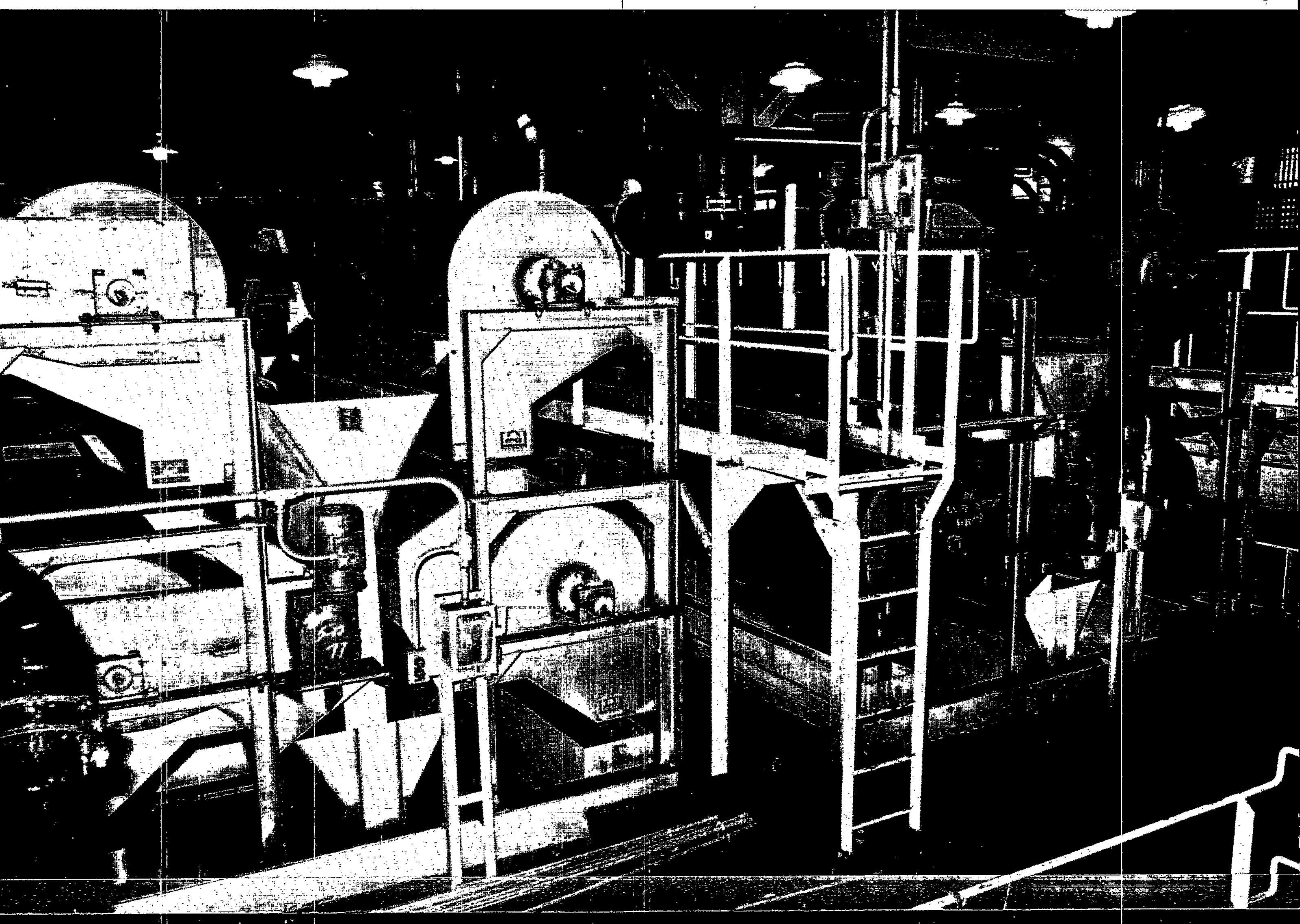
EPA

Capsule Report

First Progress Report: Physical Coal-Cleaning Demonstration at Homer City, Pennsylvania



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August 1979

This report was developed by the
Energy and Assessment Control Division
Industrial Environmental Research Laboratory
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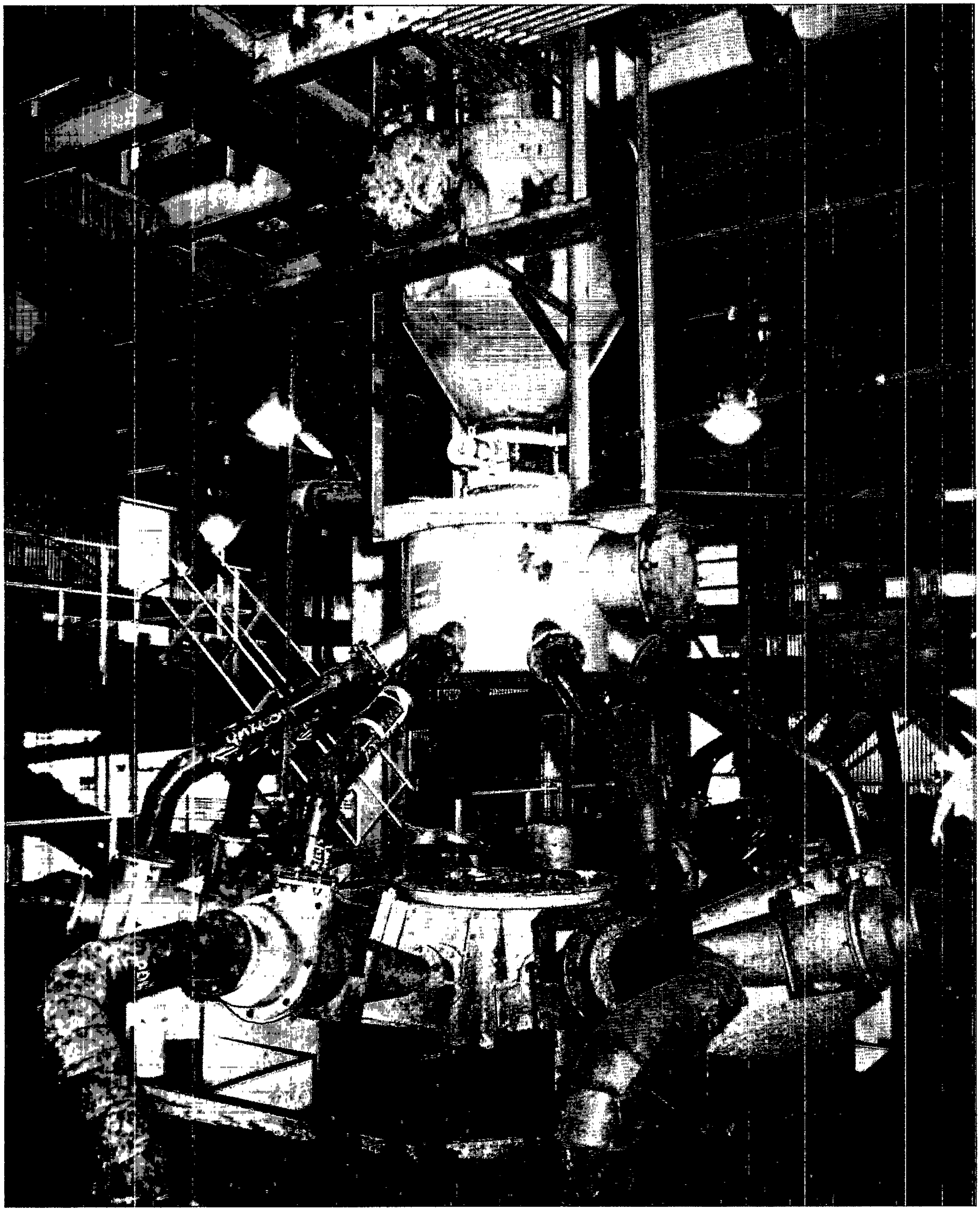


"Spider" cyclone classifier

1. Strategy

Regulations established under the Federal Clean Air Act Amendments have set primary and secondary air quality standards. Under these amendments specific standards have been established to limit sulfur dioxide (SO_2) emissions from large stationary sources such as coal-burning boilers used to generate electricity. The Clean Air Act Amendments of 1977 (Public Law 95-95) and Environmental Protection Agency (EPA) regulations promulgated in May 1979 require that all new sources implement pollution control technology to control SO_2 emissions. Consequently, sulfur-removing technologies such as physical coal cleaning (PCC), chemical coal cleaning, and flue gas desulfurization (FGD) are of increasing interest.

Sulfur appears in coal in three forms: mineral sulfur in the form of pyrite, organically bound sulfur, and sulfate sulfur in trace quantities. The success of the PCC process is because the pyritic sulfur has a higher density than the rest of the coal. Particle size is a factor in the efficiency of PCC. This process is capable of removing 40 to 90 percent of pyrite sulfur. Unfortunately, owing to the strong chemical bonding between the sulfur and the coal, the organic sulfur cannot be removed by physical separation techniques.

PCC is a viable technique in the following applications:

- Complying with SO_2 emission standards when the amount of reduction required for compliance is moderate
- Combining with FGD to lower emission control costs
- Producing several product coals, each with a different fuel sulfur value

The Pennsylvania Electric Company (Penelec) is using the third application, producing multiple product coals, at the plant that it operates in Homer City. Penelec, a subsidiary of General Public Utilities Corporation, and the New York State Electric and Gas Corporation jointly own the Homer City Generating Station, a mine-mouth, coal-fired generating station in central Pennsylvania. The plant went into commercial operation in 1969 with two 600-MW units (Units 1 and 2). A 650-MW unit (Unit 3) was recently put into commercial operation. The station uses coal from two dedicated mines, Helen and Helvetia, and from other mines nearby.

Pennsylvania's SO_2 emission regulations for large existing stationary sources outside air basins permit a maximum SO_2 emission level of 4.0 lb/10^6 Btu (7.2 g/10^6 cal). Normal run-of-mine coal from Helen and Helvetia cannot meet this requirement. The EPA adopted revised air pollution standards in May 1979 retaining the previous SO_2 emissions ceiling of 1.2 lb/10^6 Btu (2.2 g/10^6 cal) and adding the requirement to remove 90 percent of the sulfur dioxide from high sulfur coals and 70 percent from coal with an SO_2 emission rate less than 0.6 lb/10^6 Btu (1.1 g/10^6 cal). The allowable SO_2 emission rate from Unit 3 is 1.2 lb/10^6 Btu (2.2 g/10^6 Btu), based on the sulfur content of the Helen and Helvetia mined coal.

To comply with emission standards for SO_2, the Homer City owners planned to install an FGD system on Unit 3 and to construct a PCC plant to desulfurize coal sufficiently to meet the Pennsylvania regulations applying to Units 1 and 2. The PCC plant, designed and constructed by Heyl & Patterson, Inc., is currently in an early stage of operation. The facility features dense medium cyclone circuits that desulfurize the coal and optimize Btu recovery from the raw coal feed. A lime/limestone FGD system was initially selected for Unit 3 and was ordered in January 1975. This plan was later discarded, however, in favor of the strategy of using a single coal preparation plant to generate two coal product streams capable of meeting the emission regulations for both the new and existing units. The method was termed the multistream coal cleaning system (MCCS).

Indigenous coal deposits in the Penelec service territory are largely from the Allegheny series of coal seams; they have long been recognized for their suitability for desulfurization by coal cleaning because they contain both a relatively low percentage of chemically bound organic sulfur and a high but easily liberated pyritic sulfur. Favorable research and development findings on coal washing encouraged consideration of advanced preparation methods as a possible alternative to FGD at Homer City.

From a large research, development, and engineering evaluation program conducted by the owners' consultants and Heyl & Patterson, it was concluded that an advanced, state-of-the-art PCC plant to produce two coal products simultaneously could supply all necessary Homer City coal for compliance without supplemental FGD. The technology would remove 40 to 50 percent of the sulfur from the raw coal and redistribute the remaining sulfur content of the cleaned coal so that SO_2 emissions of less than 4.0 lb/10^6 Btu (7.2 g/10^6 cal) would result from Units 1 and 2 and less than 1.2 lb/10^6 Btu (2.2 g/10^6 cal) from Unit 3 (see Figure 1).

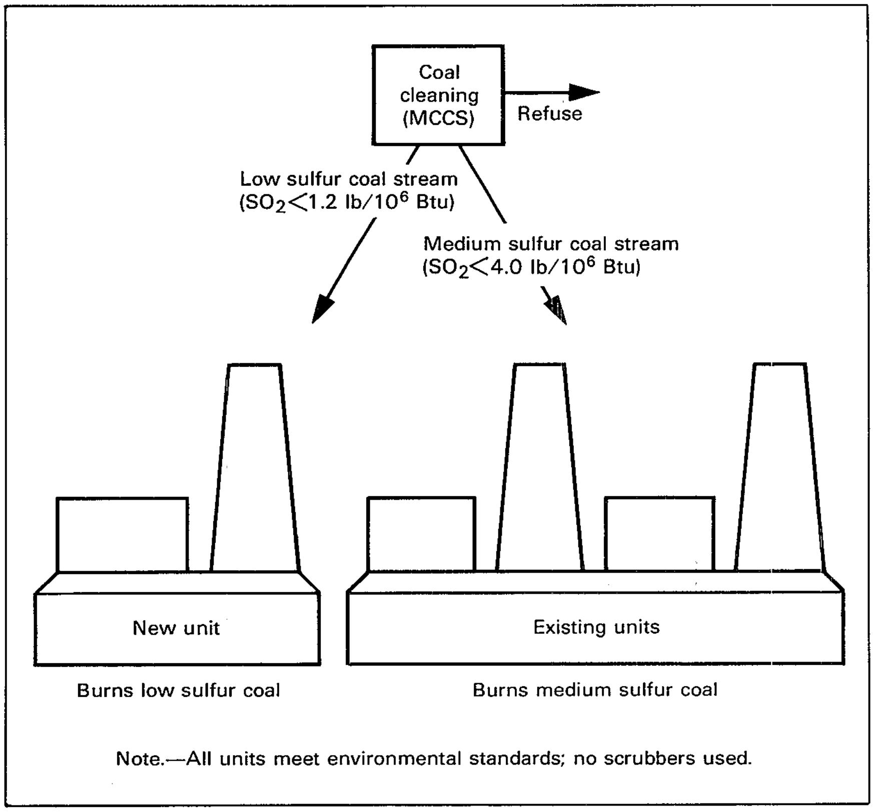


Figure 1.

The Homer City Configuration

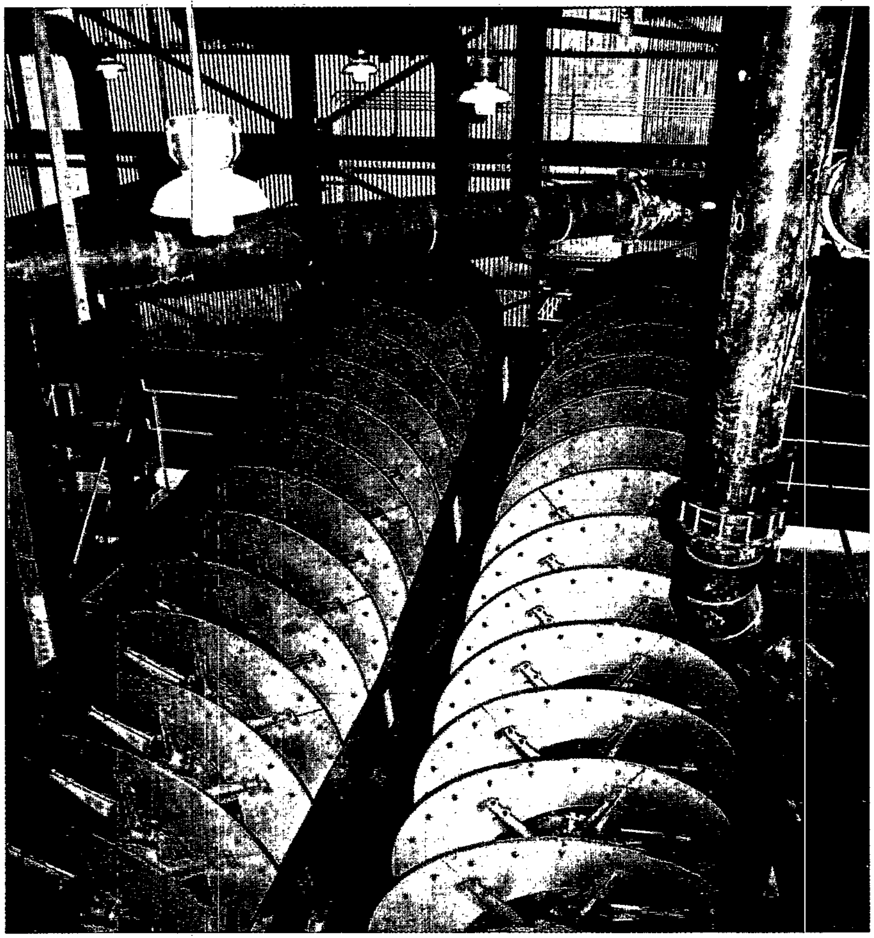
Economic studies indicated that annual revenue requirements for complying with the SO_2 emission regulations by using clean coal for the existing units and installing an FGD system on Unit 3 would exceed $20 million. In contrast, annual revenue requirements for compliance with SO_2 emission regulations in all three units using the MCCS approach would be less than $14 million.

In August 1975, the Homer City owners decided to proceed with the design and construction of new, dense medium cyclone circuits to accomplish deep coal cleaning to meet the NSPS for Unit 3. The order for the FGD system was canceled.

The basic coal-cleaning technology to be implemented at Homer City is well established; however, several new process design features and innovations will be used for the first time, including the following:

- Raw coal crushing will be controlled to minimize production of the very fine coal that is difficult to recover from the plant process water.
- Dense medium cyclones will be used to separate coal and ash at smaller particle sizes than normally are used in commercial practice.
- Full-stream electromagnetic separators will be substituted for the drain-and-rinse screens that are customarily used for magnetite recovery.
- The operating density range for dense medium cyclones will be to 110 lb/ft^3 (1.8 Mg/m^3) at the upper end and to 81 lb/ft^3 (1.3 Mg/m^3) at the lower end, so that requisite redistribution of sulfur is possible.
- A scheme will be developed to control the coal slurry medium density at the 1.3-Mg/m^3 level. This density level is vital in obtaining high yields from the deep cleaning circuits while maintaining a high efficiency of sulfur separation from coal.
- Scavenging equipment will be incorporated in the fine-coal-processing circuits to recover approximately 95 percent of the energy in the coal fed to the preparation plant.
- Efficient pollution control devices and appropriate methods of residue disposal will be employed to minimize the environmental impact of the coal cleaning. The process water will be recirculated throughout the coal-cleaning operation.

PCC implemented at Homer City may gain wide utility application as a means of controlling SO_2 emissions or as a supplement to other control technologies. Further application of PCC hinges on the establishment of its technical and economic feasibility and the identification of specific locations where it might be used.



Spiral classifier

The U.S. Environmental Protection Agency (EPA), in partnership with the Electric Power Research Institute (EPRI) and the Homer City owners, is sponsoring a 3-year project aimed at evaluating PCC technology and at assessing its applicability on a nationwide scale. The project will mainly study the Homer City coal-cleaning plant and the effects of clean coal burning on the operation and economics of power generation in all three units. Furthermore, the project will evaluate the coal reserves available to the Homer City coal-cleaning facility with respect to variability in cleaning characteristics and the effect of this variability on the properties of the clean coal.

2. Program

Homer City's MCCS is complex and serves boilers with different allowable sulfur oxide emission rates, yet it demonstrates many of the generally applicable aspects of PCC that will prove to be beneficial in other plants.

Wide application of PCC, as used at Homer City, for full or partial control of sulfur oxide emissions from utility coal burners depends on the resolution of several issues. First, the workability and practicability of the technology's novel aspects (such as separation of coal and refuse in dense medium cyclones at a density of 1.3 Mg/m^3) need to be established. Second, the economic feasibility of the concept in comparison with other SO_2 control alternatives requires a detailed assessment. These issues must be resolved successfully and the amenability of the local coal reserves to treatment by PCC must be assessed in detail (taking into account applicable sulfur oxide emission regulations) before PCC will be widely accepted as a method of complying with SO_2 emission regulations.

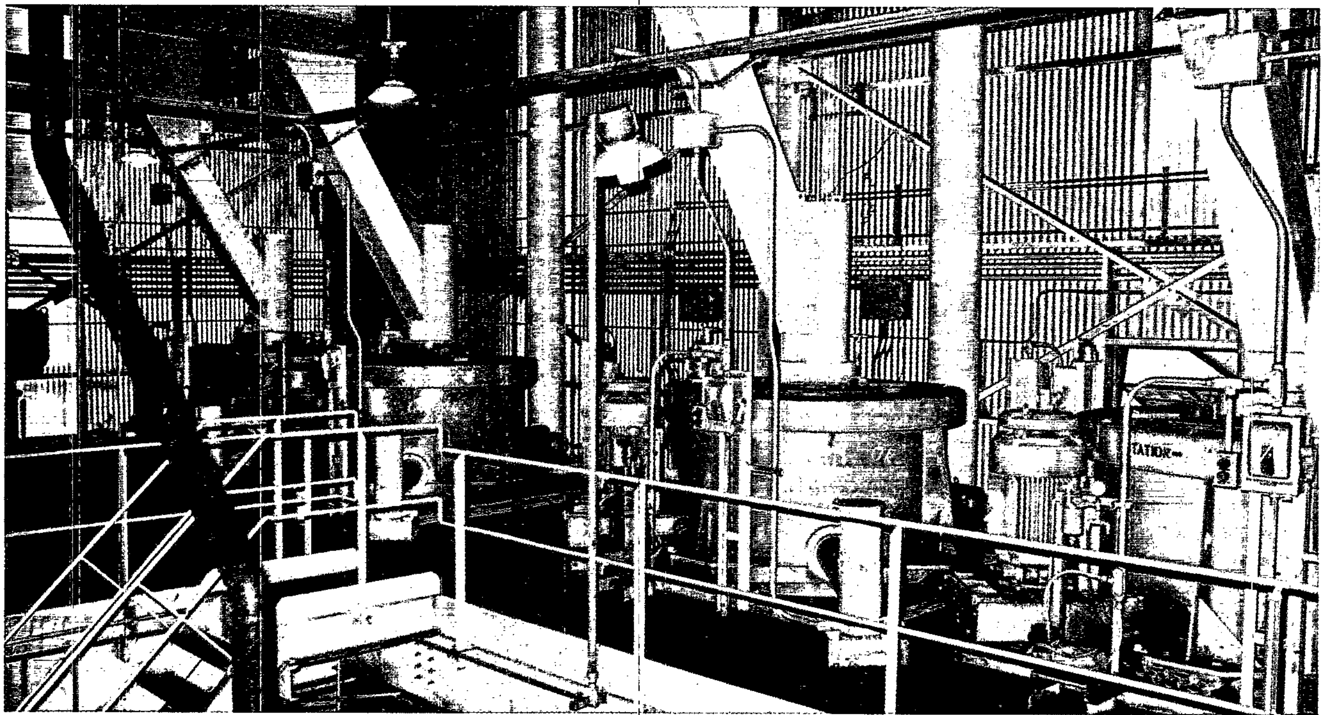
The test program has been divided into six major tasks, excluding those concerned with the management, planning, and control of the project:

- PCC test and evaluation
- Support studies for PCC test and evaluation
- Power plant test and evaluation
- Coal reserve characterization study
- Ancillary environmental tests
- Engineering studies

PCC Test and Evaluation

The coal-cleaning facility will be completely characterized. The quality and quantity of all major streams will be measured and analyzed. The performance of individual cleaning equipment and controls will be measured and assessed. In view of the expected variability of the sulfur and ash contents of the raw coal feed, the capability of the process to provide a uniform and acceptable product will be investigated. The efficiency of schemes for magnetite recovery and water recirculation will be evaluated. Consumption of magnetite, water, flocculants (for thickener operation), and energy will be determined.

To accomplish these tasks will require sampling and material flow measurement of process streams containing large amounts of coal and refuse that may or may not be present in slurry form with water and magnetite. The solids flow rate is expected to range from 100 to 1,000 tons/h (90 to 900 Mg/h). Liquid or slurry flow rates up to 15,000 gal/min (0.95 m^3/s) are anticipated. The development of accurate flow measurement, sampling, and analytical schemes is an important precursor to the plant evaluation.



Vacuum filters

Information obtained under this task will allow: determination of the technical feasibility of PCC for compliance with SO_2 emission regulations and novel process applications; gathering of sufficient technical data on equipment performance for use in comprehensive computer modeling of advanced coal cleaning, to be carried out under the support studies task; determination of the quality and quantity of effluent waste streams and emissions; and determination of the economic feasibility of PCC compared with that of other control alternatives.

Support Studies for PCC Test and Evaluation

The U.S. Department of Energy (DOE) now operates a pilot plant in Bruceton, Pennsylvania. It is the main objective of the pilot plant tests to provide technical data on factors affecting separation of coal from refuse in dense medium cyclones under conditions used in the Homer City cleaning plant. Factors such as the magnetite particle size, cyclone orifice size ratios, cyclone inlet pressures, dense medium viscosity, medium density, and the proportion of coal to dense medium (pulp density) can all be varied easily in the pilot plant and their effects on separation efficiency can be determined. The resulting information will be used by the operators of the Homer City plant.

Equipment performance data obtained from the PCC evaluation and the DOE pilot plant will provide the information base needed for ongoing computer modeling, sponsored by EPA, aimed at facilitating the design and cost estimation of advanced cleaning plants. The computer model will be versatile enough to specify the required processing of any washable raw coal to achieve a cleaned coal of a certain quality.

Power Plant Test and Evaluation

It is anticipated that burning coal of uniform quality with reduced sulfur and ash content will lead to more economical and reliable boiler operation. Some uncertainties still exist, however, concerning the effect of the altered coal properties on the operation of the boiler and the collection efficiency of stack gas particulate control devices.

Preliminary laboratory tests have revealed some problems with the burning of cleaned Homer City coal. The ash in the cleaned coal seems to have a higher slagging potential; that is, the molten ash does not flow as readily as is necessary for efficient boiler operation. This characteristic leads to undesirable deposits on heat exchange surfaces; more frequent load cutbacks are then required for manual or automatic steam cleaning. It is also anticipated that the lower sulfur content of the coal will cause the resistivity of the ash particles in the flue gas to increase, resulting in a drop in collection efficiency in the electrostatic precipitators (ESP's) used for fly ash collection. This efficiency loss may be offset by the decreased dust loading to which the units will be subjected when firing very low ash coal.

The effects of burning the deep-cleaned coal (versus those of burning raw coal) on boiler performance will be investigated by monitoring and testing Unit 3 in the power-generating complex. The tests will include sampling and analyzing the fuel fly ash and flue gas, measuring unit efficiency, and monitoring boiler maintenance and cleanup operations. Data on the economics of power generation using clean coal also will be extracted. These tests will point out any ash slagging problems in burning the deep-cleaned coal and their effects on power costs.

The performance of the ESP's on Units 1, 2, and 3 will be closely monitored. Inlet and outlet fly ash loadings and characteristics, together with sampling of the flue gas for O_2, CO_2, SO_2, and SO_3 content, will provide data necessary for evaluating the performance of the collection devices on flue gases resulting from the combustion of:

- High sulfur, high ash fuel
- Medium sulfur, high ash fuel
- Low sulfur, low ash fuel

The foregoing tests will determine the effects of sulfur content of the fuel on the performance of ESP's.

Coal Reserve Characterization

EPA is currently sponsoring a program, conducted by the U.S. Bureau of Mines and the U.S. Geological Survey, aimed at assessing the cleanability of U.S. coals, including those of the Helen and Helvetia mine reserves. Extensive analysis of core samples and samples obtained by mining methods will yield significant information concerning:

- The geographic variability of sulfur and ash in the available seams
- The variation in washability characteristics within the seam
- The relationship between sulfur/ash content and mining (or sampling) methods (mechanized mining methods cause the entrainment of more refuse in the raw coal)

Information obtained under this task will help establish an economic mining or blending scheme that would reduce the variability of the sulfur in the feed to the coal-cleaning plant. This approach would minimize short-term sulfur emissions from the power plant and facilitate equipment and process control in the coal-cleaning plant.

Ancillary Environmental Testing

Environmental impacts associated with disposal of solid and liquid wastes will be investigated. Studies are concerned with pollutants that may be considered hazardous or toxic under the provisions of the Water Pollution Control Act (priority pollutants), the Resource Conservation and Recovery Act (hazardous wastes), the 1977 Clean Air Act Amendments (hazardous air pollutants), or the Toxic Substances Control Act.

The primary intent of the environmental assessment activities is to identify pollutants that pose a threat to health or to the ecology and to devise cost-effective strategies for dealing with them. These pollutants are associated with various sources, for example, the leachates (contaminated water) from collecting ponds, coal and residue storage piles, and combustion ash refuse disposal areas. The leachates may be acidic and may contain dissolved heavy metals, sulfates of iron, and so forth. They are generated by runoff and percolation of rain water through the residue piles and by seepage of pond water. There is also a potential for fugitive dust emission from coal and ash piles.

Leachates will be characterized and their magnitudes measured by drilling strategically located wells that extend beyond the strata underlying the piles and the collecting ponds. The rate of flow of ground water will be determined and samples will be collected and analyzed for contaminants. Ambient air will be sampled to determine the concentration of fugitive dust.

The information obtained through environmental testing will aid in evaluating current waste disposal methods and will help to determine more efficient pollution control measures. It will also be helpful in comparing the environmental impacts of power generation using PCC with those of power generation using other control alternatives for sulfur oxides.

Engineering Studies

Three projects will be undertaken to enhance product quality control and the efficiency of sulfur removal and coal recovery at the cleaning plant. These projects will consist of:

- Evaluating a process to recover magnetite from power plant fly ash
- Developing and evaluating a nuclear probe for the in-line determination of sulfur and ash in the product coal
- Optimizing the raw coal comminution (crushing) process to maximize the release of pyrite and minimize the production of fine product

Magnetite Recovery. Section 3 describes the use of suspensions of magnetite in water to effect the separation of pyrite from coal at the Homer City coal-cleaning plant. Although the plant design incorporates advanced schemes for magnetite collection and recovery, losses ranging between 2 and 5 lb/ton (1 and 2.5 kg/Mg) of product coal are anticipated. These losses represent about 10 percent of the plant operating cost of coal cleaning.

In addition to maximizing the percentage of magnetite recovery, the Homer City owners have performed preliminary studies on the extraction of iron oxides from power plant fly ash. This may be accomplished by dry magnetic separation followed by a wet separation and milling of the resultant concentrate to the desired particle size distribution. To evaluate the suitability of this magnetite for coal/refuse separation, as carried out at Homer City, some tests will be made at the DOE pilot plant. Full-scale testing in one of the dense medium cyclones will be conducted later.

On-Line Sulfur and Ash Measuring Instrument. Development of an instrument capable of continuously measuring the sulfur and ash content of the product coal would contribute significantly to solving the problem of product quality control at coal-cleaning plants. Work sponsored by the Homer City owners has resulted in the development of a prototype sulfur and ash meter. A high energy neutron beam from the instrument strikes the surface of a coal or ash particle and results in the emission of secondary radiation. This radiation is detected and resolved electronically, indicating the elemental constituents of the irradiated particles.

The prototype meter is to be installed at the Homer City plant. Its ability to continuously and accurately measure coal and ash properties will be evaluated.

Comminution Studies. Controlled crushing of raw coal is necessary before washing to separate the ash and pyrite present in the mined coal, with two objectives: to maximize the degree of segregation of ash and coal particles and to minimize the production of fine particles (lower than 100 mesh). Coal/refuse separations at sizes below 100 mesh are costly and less efficient.

Several comminution studies are proposed for optimizing the crushing operation at the Homer City plant:

- Washability tests of the natural particle size fractions of the raw coal will be performed.
- Tests will be conducted of the commercial crusher at the Homer City plant. In these tests operating conditions will be varied to obtain different proportions of the size fractions of interest.
- Chemical comminution of the various sizes of coal in ammonia will be performed to determine the potential for improved liberation of mineral matter from the coal particles. It is thought that this method of comminution causes a separation of coal and refuse along the surfaces of the particles, which leads to maximum segregation.

3. The Coal-Cleaning Plant

The Homer City plant contains two parallel coal-cleaning circuits, each capable of independent production and each designed for continuous operation. Provisions for storage of a supply of each product coal have been included in the plant design, allowing either or both circuits to be shut down for maintenance without interrupting power generation. As stated earlier, the Homer City Generating Station receives the major part of its coal from the nearby Helen and Helvetia mines, and additional coal is shipped by truck from other mines in western Pennsylvania. Most of the coal is characterized by a low organic sulfur content (less than 0.6 percent) and a high ratio of pyritic to organic sulfur (about 3:1). The pyritic sulfur is liberated relatively easily from the coal matrix by crushing.

In the coal-cleaning plant, the coal is processed to obtain two clean coal products: one to meet SO_2 emission regulations of 4.0 lb/10^6 Btu (7.2 g/10^6 cal) for Units 1 and 2, and one to meet the SO_2 emission regulations of 1.2 lb/10^6 Btu (2.2 g/10^6 cal) for Unit 3. Coal refuse is also generated; this material is dewatered and discarded in a refuse disposal area. Specifications for the coal products and the refuse material are shown in Table 1.

The coal-cleaning circuits at Homer City are shown schematically in Figures 2 and 3. Figure 2 represents the coarse-cleaning circuit, which consists of crushers, screens, dense medium cyclones, and centrifuges. The fine coal circuit, shown in Figure 3, contains dense medium cyclones, hydrocyclones, Deister tables, spiral classifiers, centrifuges, vacuum filters, thickeners, and other equipment necessary to the classification and recovery of fine coal. Both figures are greatly simplified for clarity in illustration.

Coarse Coal Procedures

Run-of-mine coal is first crushed in cage crushers to a top size of 1.25 inch (31.8 mm). This operation is carefully controlled to minimize the production of sizes larger than 0.25 inch (6.35 mm) and smaller than 100 mesh (0.15 mm). In the crusher, the coal is introduced into the center of an open impeller that spins at high speed and flings the coal outward against round cage bars.

Table 1.

Homer City Plant Production Specifications

Item	Medium sulfur coal	Low sulfur coal	Refuse
Weight distribution (percent)	56.2	24.7	19.1
Energy distribution (percent)[a]	61.6	32.9	5.5
Energy content (Btu/lb dry basis)	12,500	15,200	3,400
Ash content (percent)	17.75	2.84	69.69
Sulfur content (percent)	2.24	0.88	6.15
SO_2 emission factor (lb/10^6 Btu)	3.6	1.2	65.9

[a]Overall plant Btu recovery is 94.5 percent, which includes 1 percent credit for thermal drying loss.

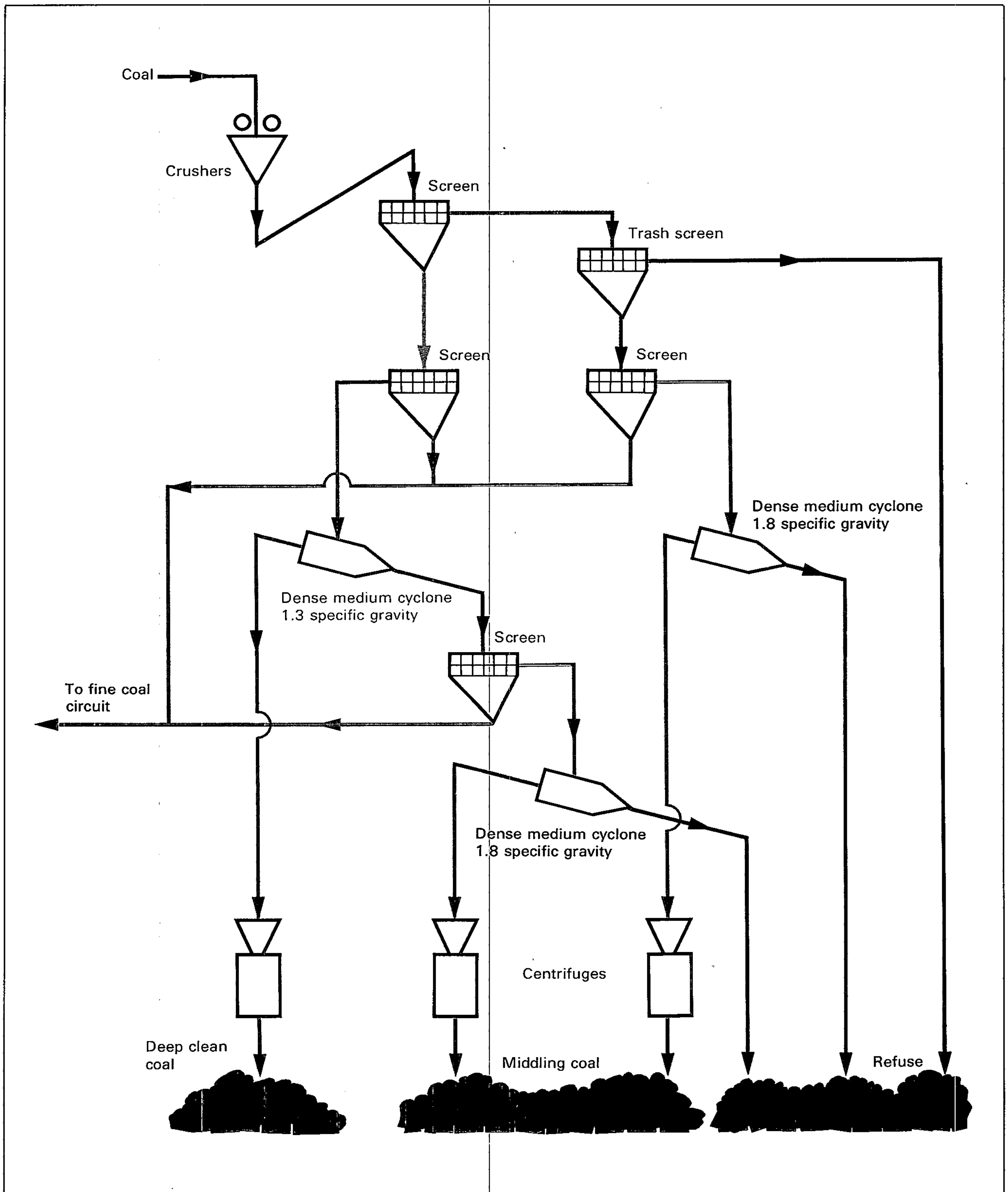


Figure 2.

Coarse-Coal-Cleaning Circuit

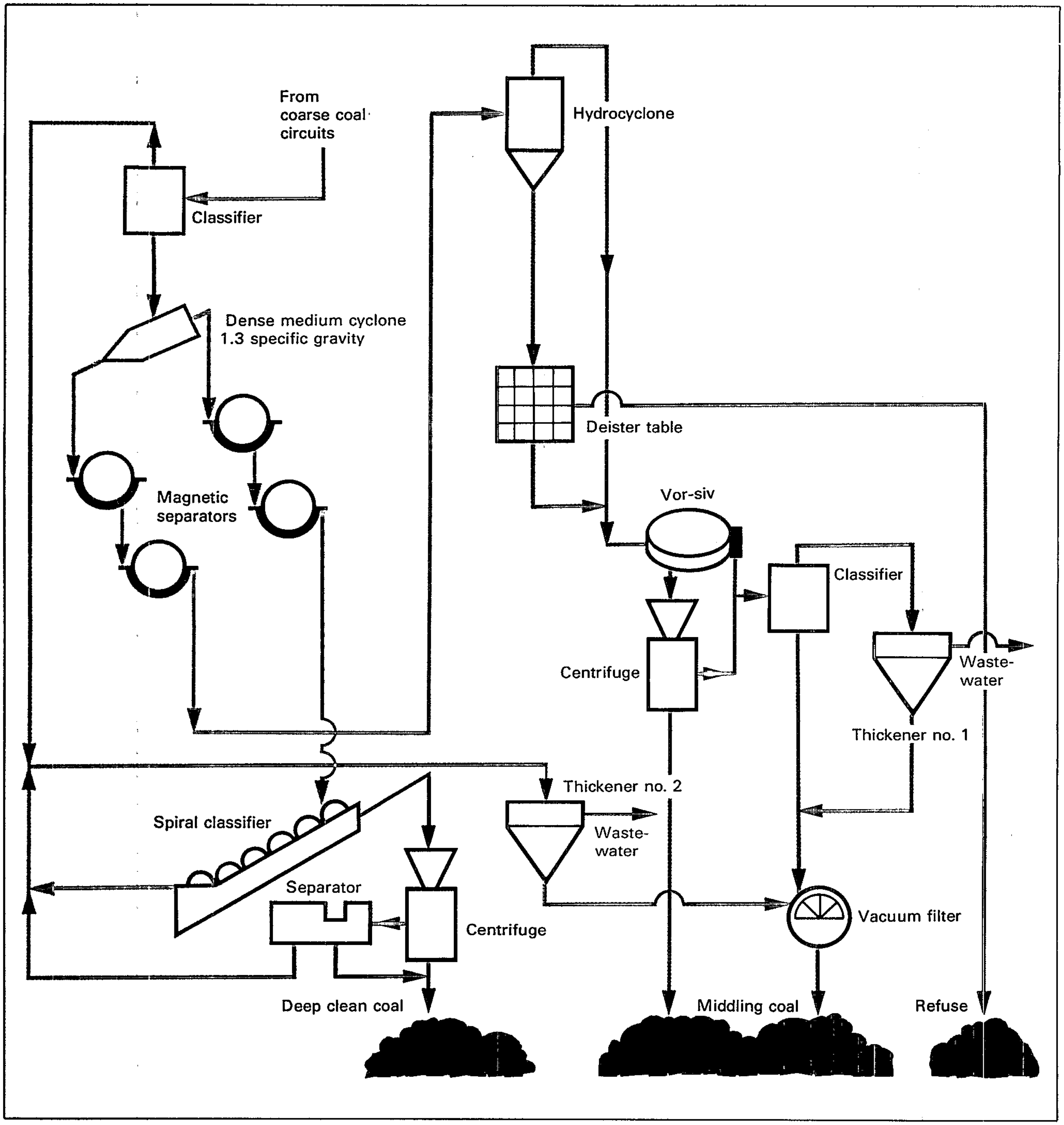


Figure 3.

Fine-Coal-Processing Circuit

After crushing, the coal is segregated into various size fractions by using several horizontal vibrating stainless steel wedge-wire mesh screens. Coal of a given size fraction is then processed separately, using dense medium cyclone circuitry. A typical cyclone is shown schematically in Figure 4. The dense medium, which is a water slurry containing very finely divided magnetite, acts essentially as a liquid in its action on larger particles of coal and refuse. Particles more dense than the apparent density of the magnetite slurry tend to sink, whereas particles less dense than the slurry will float. Pyrite and ash-forming minerals, being heavier per unit volume than the dense medium, are selectively concentrated in an underflow fraction. Clean coal particles, composed primarily of less-dense carbon, tend to become concentrated in an overflow stream. The slurry is fed tangentially into the cyclone, and the joint action of gravity and centrifugal force aids the separation of dense and light particles. Those particles which tend to float in the medium move toward the axis of the cone and exit through a pipe fixed to the base and jutting into the cone a short distance toward the apex. This pipe is called a vortex finder. Particles that tend to sink in the medium move toward the wall of the cone and are carried toward the apex. The stream exiting tangentially from the top of the cyclone is a slurry of clean coal, while slurry leaving at the base contains refuse. The clean coal and refuse streams are passed over screens and magnetic separators to recover the magnetite. The clean coal product stream may then pass through further separation stages, or it may be dewatered and dried. The refuse stream is dewatered before disposal.

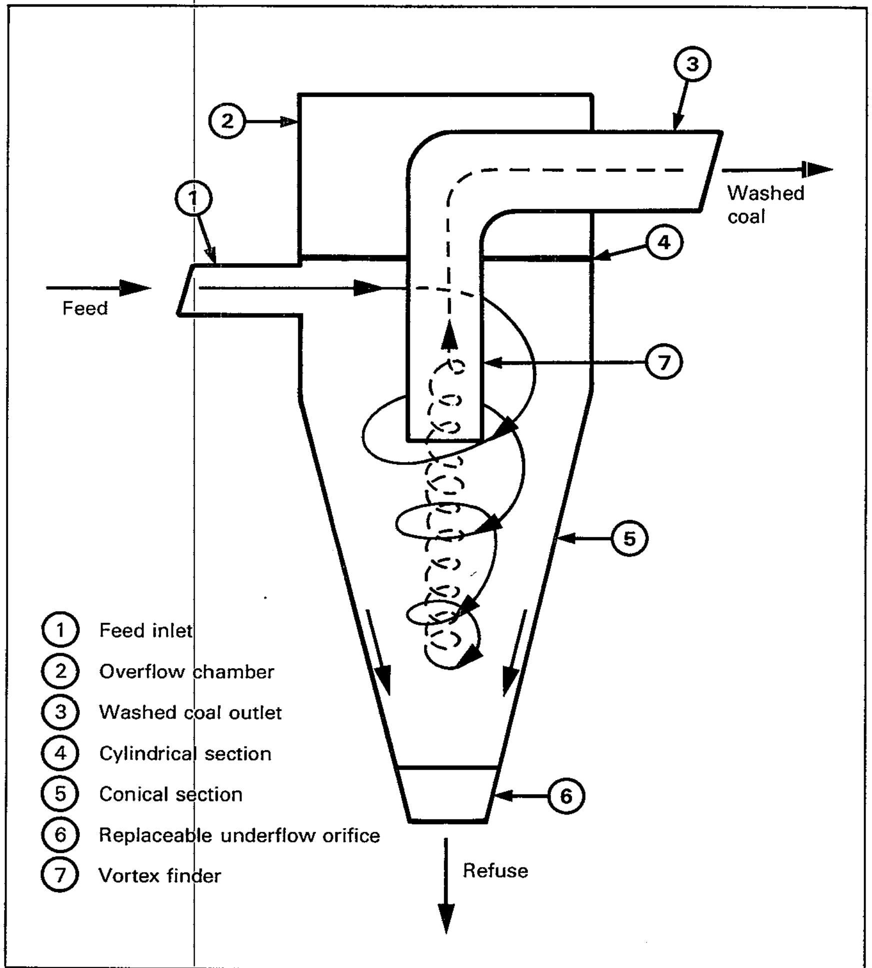


Figure 4.

Dense Medium Cyclone

Basket centrifuges operating on a vertical axis are used for final dewatering of the product. The rapidly spinning basket forces water through the basket openings and solids are trapped on the basket surface. After discharge from the centrifuge, the coal solids are dried in a fluidized bed drier where hot combustion gases are blown through a bed of coal particles. The coal/gas mixture behaves like a turbulent fluid providing for excellent mixing of particles and ensuring intimate gas-solid contact.

Fine Coal Procedures

The unusual features of the Homer City plant are found in the circuits (Figure 3) that process coal finer than 0.079 inch (2 mm). One unusual feature is the cleaning of coal as finely divided as 100 mesh (0.15 mm); most coal-cleaning plants segregate and exclude particles smaller than about 28 mesh (0.59 mm) in dense medium circuits. At Homer City, the fine coal is processed by first separating particles smaller than 100 mesh (0.15 mm) in cyclone classifiers. A cyclone classifier operates in essentially the same manner as a dense medium cyclone, except that the centrifugal force segregates the fine coal particles of 100 mesh (0.15 mm) or larger. These larger coal particles flow to the base of the classifying cyclones, and the fine coal exits from the top. Underflow from the classifiers is then mixed with dense medium, under automatic control from complex instrumentation.

The underflow mixture is then treated in dense medium cyclones, where almost half the coal is removed as deep-cleaned product at a separation density of about 1.3 Mg/m^3. An extensive series of preliminary tests has shown that the coals from this coal reserve region can be crushed so that particles of 0.079 inch by 100 mesh (2 mm by 0.15 mm) are to a large extent distinct particles of either mineral or carbon, and so that a sharp separation of pyritic sulfur and ash can be effected if close control of the cyclone operating conditions is maintained. The deep-cleaned product is expected to contain consistently less than 0.9 percent sulfur, and more than two-thirds of the coal burned in the new boiler will be produced from these cyclones.

To clean particles as small as 100 mesh (0.15 mm) it has been necessary to include another uncommon feature at the Homer City plant. Conventional mechanical screening could not be used to segregate magnetite for recycling. Instead, both the overflow and the underflow from the dense medium cyclones are passed through two banks of magnetic separators. The cleaned coal is subsequently separated from water in spiral classifiers and dewatered in two stages of centrifugation.

Magnetic separators are large, fixed permanent magnets inside a rotating, nonmagnetic shell onto which the medium is distributed. The magnetite is then held to the drum and is carried by rotation to a recovery trough outside the area of influence from the fixed magnets.

The spiral classifiers accomplish separation by a combination of centrifugal and gravitational forces. The classifier consists of a spiral conduit through which feed slurry is introduced. The slurry flows down until the centrifugal forces cause the heavier particles to stratify. The two streams are then separated to give a clean coal product and a middlings product.

The rest of the plant consists of equipment to reclaim more of the middlings coal and to condition the processing water for recycling. Part of the remaining coal is cleaned on Deister tables to remove refuse after being dewatered in hydrocyclones. A Deister table consists of a large flat surface that is inclined slightly both front to back and left to right. The smooth surface is divided into narrow strips by riffles that form a large number of parallel channels approximately 0.5 inch (12.7 mm) deep by 0.5 inch (12.7 mm) wide. Coal slurry is fed in and the table is vibrated. Lighter and smaller particles tend to flow predominately with the water flow; denser and larger pieces move in the direction of stroke until they fall over the edge of the table into a collecting sluice.

A variety of centrifugal and static thickeners is used to concentrate suspended coal solids that remain in the processing water. The finest solids are separated by vacuum filtration, and complete closed-loop recycling of process water is practiced during operation.

Some of the centrifuges are of the basket type, described earlier, and others are of the solid bowl type. The solid bowl centrifuge contains a horizontal, high speed, rotating bowl. Segregated water overflows at the top of the bowl while the solids are removed via a helical screw conveyor at the base.

Static thickeners are large tanks that allow fine, suspended solids in a slurry to settle by gravity. The partially dewatered solids are then removed by rakes from the bottom of the tank.

Vacuum filters are mechanical devices that remove water from various thickener sludges by applying a suction across the filtering medium. The water is drawn through the filter while solids are trapped on the porous metal filter medium.

4. Other Coal-Cleaning Applications

Successful implementation of the MCCS concept at Homer City will provide some coal-burning power plants with an alternative SO_2 control technique that may be economically preferable to FGD or the long-range transportation of low sulfur coals. For any specific location, three criteria should be met before the concept is applied:

- Available coal mine reserves should be amenable to sulfur removal by PCC methods. To be amenable, the coal should have a ratio of pyritic to organic sulfur on the order of 2:1 to 4:1.
- SO_2 emissions resulting from burning the clean coal should meet Federal or local regulations.
- If coal cleaning is to be used as a sulfur oxide control measure, the overall economics should be proved more favorable than those of currently available sulfur oxide control alternatives.

The PCC concept also may be used in combination with FGD and other advanced SO_2 control technologies, including fluidized bed combustion and coal gasification and liquefaction, to reduce the cost of compliance with sulfur oxide regulations. In these applications, the deep-cleaned coal would be burned in new units for which NSPS are applicable, in old units for which it is usually not economically attractive to retrofit FGD systems and for which regulations require a reduction in sulfur oxide emission, and in other areas where the need for SO_2 control is more critical. Clean coal with a high sulfur content either may be treated for sulfur removal before combustion, as in liquefaction and gasification, or may be subject to FGD after combustion. It is believed that this scheme would effect substantial savings in capital and operating costs compared with an approach that uses the advanced desulfurization technique exclusively.

It is estimated that vast coal reserves in which sulfur content is mainly in the pyritic form (as is true of the Homer City coal) exist in the eastern Appalachian coal basin, especially in central Pennsylvania, Maryland, and West Virginia. There are believed to be 10 billion tons of washable coals in central Pennsylvania alone.

Aside from SO_2 control, coal cleaning before combustion may have other beneficial effects in power generation. The resulting improvement in coal quality may increase boiler availability and generating capacity, thereby reducing operating and maintenance costs of the boiler and of any particulate and SO_2 control systems downstream. Increased boiler availability could effectively reduce the necessary generating reserve requirement of existing electrical systems. It would postpone the installation of new and expensive generating capacity. The PCC evaluation program will help to resolve cost uncertainties associated with the combustion of cleaned coals.

System for conveying coal to cleaning plant

This report was prepared for the U.S. Environmental Protection Agency by PEDCo Environmental, Inc., in Cincinnati OH. Principal contributors were Dr. Robin D. Tems and Dr. Gerald A. Isaacs. Mr. James D. Kilgroe, the EPA Coal Cleaning Program Manager, served as the technical coordinator for the report. Mr. Kilgroe is with the Industrial Environmental Research Laboratory's Fuel Process Branch in Research Triangle Park NC. Technical assistance was provided by the Pennsylvania Electric Company.

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