FOSSIL

DOE/MC/27362--3860
(DE94012286)

Blast Furnace Granular Coal Injection Project

Annual Report
January - December 1993

June 1994

Work Performed Under Cooperative Agreement No.: DE-FC21-91MC27362

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Bethlehem Steel Corporation
Bethlehem, Pennsylvania

DOE/MC/27362--3860
(DE94012286)
Distribution Categories UC-102 and UC-104

Blast Furnace Granular Coal Injection Project

Annual Report
January - December 1993

Work Performed Under Cooperative Agreement No.: DE-FC21-91MC27362

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880

By
Bethlehem Steel Corporation
C229, Research Department
701 East Third Street
Bethlehem, Pennsylvania 18016

June 1994

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	BACKGROUND	1
3.0	TECHNOLOGY DESCRIPTION	2
4.0	PROCESS DESCRIPTION	5
	4.1 SITE LOCATION	5
	4.2 RAW COAL HANDLING EQUIPMENT	5
	4.3 COAL PREPARATION FACILITY	6
	4.4 COAL INJECTION FACILITY	7
5.0	PROJECT DESCRIPTION	7
	5.1 COAL GRIND SIZE	7
	5.2 COAL INJECTION RATE	8
	5.3 COAL SOURCE	8
	5.4 BLAST FURNACE CONVERSION METHOD	8
	5.5 PROJECT SCOPE	9
6.0	FIRST QUARTER ACCOMPLISHMENTS	9
7.0	SECOND QUARTER ACCOMPLISHMENTS	9
8.0	THIRD QUARTER ACCOMPLISHMENTS	10
9.0	FOURTH QUARTER ACCOMPLISHMENTS	10
10.0	PROJECT STATUS	10
	10.1 ENGINEERING STATUS	10
	10.2 CONSTRUCTION STATUS	11
11.0	REFERENCES	12

LIST OF FIGURES

Figure 1.	The Steelmaking Process
Figure 2.	The Blast Furnace Complex
Figure 3.	Zones in the Blast Furnace
Figure 4.	Coal Injection Test Program Parameters
Figure 5.	Application of Coal Injection
Figure 6.	Coal Injection Test Site/Facilities
Figure 7.	Coal Injection - Burns Harbor Plant
Figure 8.	Coal Injection Test Program Goals
Figure 9.	Project Schedule
Figure 10.	Project Milestone Schedule
Figure 11.	Project Summary Cost Estimate
Figure 12.	Phase I & II Organization
Figure 13.	Phase III Organization
Figure 14.	Project Construction Organization
Figure 15.	Bethlehem Steel BFGCI Project
Figure 16.	Utility Building - Conduit to Injectors
Figure 17.	Process Structure - Underfloor Conduit for Injectors
Figure 18.	Coal Reclaim Tunnel Looking Northeast
Figure 19.	Coal Reclaim Tunnel Looking North
Figure 20.	Process Structure/Utility Building Looking Northwest

1.0 INTRODUCTION

This initial annual report describes the Blast Furnace Granular Coal Injection project being implemented at Bethlehem Steel Corporation's (BSC) Burns Harbor, Indiana, plant. The project is receiving cost-sharing from the U.S. Department of Energy (DOE), and is being administrated by the Morgantown Energy Technology Center in accordance with the DOE Cooperative Agreement No. DE-FC21-91MC27362.

This installation will be the first in the United States to employ British Steel technology that uses granular coal to provide part of the fuel requirement of blast furnaces. The project will demonstrate/assess a broad range of technical/economic issues associated with the use of coal for this purpose. These include: coal grind size, coal injection rate, coal source (type) and blast furnace conversion method. To achieve the program objectives, the demonstration project is divided into the following three Phases:

Phase I	-	Design
Phase II	-	Construction
Phase III	-	Operation

Preliminary Design (Phase I) began in 1991 with detailed design commencing in 1993. Construction at Burns Harbor (Phase II) began in August 1993. Construction is expected to complete in the first quarter of 1995 which will be followed by the demonstration test program (Phase III).

2.0 BACKGROUND

Bethlehem Steel Corporation's Burns Harbor Plant operates two blast furnaces which produce molten iron in support of steelmaking operations. The furnaces are fueled with coke as part of the raw materials charged through the top of the furnace. The coke is supplemented by fuel, presently natural gas, injected along with the combustion air through ports (tuyeres) near the base of the furnace. Each furnace produces about 7000 tons per day of product iron with the injected fuel providing about 15 percent of the total fuel requirements.

Because of the uncertainty of the long-term supply and cost of natural gas, Bethlehem, on August 23, 1989, submitted a project in response to DOE's CCT-III solicitation that will demonstrate the conversion for, optimization of, and commercial performance characteristics of granular coal as a supplemental fuel for steel industry blast furnaces. Operating blast furnaces with coal injected directly through the tuyeres into the combustion zone as a supplemental fuel will result in reduced coke consumption, thereby decreasing the environmental emissions associated with cokemaking. The environmental problems normally associated with the combustion of coal will also be virtually eliminated by direct injection of coal into the blast furnaces as the potential contaminants, e.g., sulfur, are inherently captured in the blast furnace slag.

Economic benefits will be realized by the reduced demand for coke, the primary blast furnace fuel, and for natural gas and oil, the "conventional" supplementary fuels. Presuming that: (a) the granular coal injection system can be successfully operated at rates of several hundred pounds of coal injected per net ton of hot metal (liquid pig iron produced by the blast furnaces), and that (b) costs for the competing supplemental fuels, natural gas and oil, escalate in a manner projected by the U.S. Department of Energy (DOE), then the annual operating cost savings should make this an attractive investment as well as a technical advancement.

Following an extensive review by the DOE, Bethlehem's innovative Blast Furnace Granular Coal Injection System Demonstration Project was one of 13 demonstration projects accepted for funding in the Clean Coal Technology Program third round of competition. A cooperative agreement with a total estimated cost of $143,800,000 was awarded to Bethlehem on November 26, 1990. Under this cooperative agreement, Bethlehem would provide 78.3 percent of the total funding requirements for the demonstration project with the DOE providing the remaining 21.7 percent. As project details were refined, the cost estimate was increased from $143,800,000 to $190,650,000. Additional information including the Project Schedule, Milestone Schedule, Updated Summary Cost Estimate and Project Organization Charts are shown on Figures 9 through 14.

3.0 TECHNOLOGY DESCRIPTION

Blast furnaces produce hot metal, which is used in the basic oxygen furnaces for refinement into various grades of steel. Major ingredients in the production of hot metal are iron ore, coke and limestone. As shown on Figure 1, the ironmaking blast furnace is at the heart of the integrated steelmaking process. Fine iron ore is agglomerated by pelletizing or sintering. The prepared ferrous materials, along with coke, are charged alone or in combination with lump iron ore into the blast furnace. Preheated air is injected near the bottom of the furnace and ferrous materials are reduced and melted by hot combustion products from the burning coke to produce molten iron. The molten iron is combined with scrap and flux and is refined in the steelmaking process. The basic oxygen furnace is the predominant method used in integrated steelmaking.

Figure 2 provides more details on the blast furnace operation. As shown, the raw materials (ore, coke and limestone) are conveyed to the top of the furnace either on a conveyor belt or in a "skip" car. All or part of the limestone (and dolomite) which is used as flux to remove contaminants in the coke and ore, can be charged directly or combined in the ferrous sinter and pellet feed during their production.

The raw materials are charged to the top of the furnace through a lock hopper arrangement, to prevent the escape of pressurized hot reducing gases. Air needed for the combustion of coke to generate the heat and reducing gases for the process is passed through stoves and heated to 1500-2300°F. The heated air (hot blast) is conveyed to a refractory-lined bustle pipe located around the perimeter of the furnace. The hot blast then enters the furnace through a series of ports (tuyeres) around and near the base of the furnace. The molten iron and slag are discharged through openings (tapholes) located below the tuyeres. Resultant molten iron flows to refractory-lined ladles for transport to the steelmaking shop.

A schematic showing the various zones inside the blast furnace is given on Figure 3. As can be seen, the raw materials, which are charged to the furnace in batches, create discrete layers of ore and coke. As the hot blast reacts with and consumes coke at the tuyere zone, the burden descends in the furnace resulting in a molten pool of iron flowing around unburned coke at the furnace bottom (bosh area). Reduction of the descending ore occurs by reaction with the rising hot reducing gas that is formed when coke is burned at the tuyeres.

The cohesive zone directly above the tuyeres is so called because it is in this area that the ore, which has been reduced is being melted and passes through layers of unburned coke. The coke layers provide the permeability needed for the hot gases to pass through this zone to the upper portion of the furnace. Unlike coal, coke has the qualities needed to retain its integrity in this region and is the reason that blast furnaces cannot be operated with no coke in the burden.

The hot gas leaving the top of the furnace is cooled and cleaned. Since it has a significant heating value (80-100 BTU/scf), it is used to fire the hot blast stoves. The excess is used to generate steam and power and for other uses within the plant.

Over the years many injectants (natural gas, tar, oils, etc.) have been used in blast furnaces to reduce the amount of coke used. Their use is a matter of economics with each location making choices considering the site specific relative costs of coke and injectants available. Natural gas has been a common injectant used in this country. Recent technological developments in Europe and Asia, where coal has been widely used as an injectant, have established that the highest levels of injection and subsequent displacement of coke can be obtained by using coal.

Coal injection into blast furnaces dates back more than 100 years; it was the first fuel known to have been injected. In the United States, pulverized coal has been injected into blast furnaces at the Ashland Kentucky Plant of Armco Steel since the mid-1960's. However, different economic situations at other facilities in the United States precluded wide application of coal injection technology. That situation has changed and a number of steel companies in the U.S. have installed or are planning to install coal injection facilities.

As with other companies, Bethlehem Steel has monitored the progress of blast furnace coal injection developments worldwide for a number of years. The development and application of a process that permits the use of granular coal caught our interest. The equipment used provided the capability of injecting either granular or pulverized coal with the option of long-term use of the less expensive granular type.

The joint development between British Steel and Simon-Macawber of a process for the injection of granular coal into blast furnaces began in 1982 on the Queen Mary Blast Furnace at the Scunthorpe Works. [1,2] The objective of the development work was to inject granular coal into the furnace and test the performance of the Simon-Macawber equipment with a wide range of coal sizes and specifications. Based on Queen Mary's performance, coal injection systems were installed on Scunthorpe's Queen Victoria, Queen Anne and Queen Bess (operational standby) blast furnaces and on Blast Furnaces 1 and 2 of the Ravenscraig Works.

Queen Victoria's system was brought on line in November, 1984 and Queen Anne's in January, 1985. The Ravenscraig systems were started up in 1988. The success of the GCI systems at Scunthorpe and Ravenscraig although demonstrated on smaller blast furnaces, led Bethlehem to conclude that the system could be applied successfully to large blast furnaces using domestic coals.

A major consideration in evaluating coal injection in the United States is the aging capacity of existing cokemaking facilities and the high capital cost to rebuild these facilities to meet emission guidelines under the Clean Air Act Amendments. The increasingly stringent environmental regulations and the continuing decline in domestic cokemaking capability will cause significant reductions in the availability of commercial coke over the coming years. Due to this decline in availability and increase in operating and maintenance costs for domestic cokemaking facilities, commercial coke prices are projected to increase by more than general inflation. Higher levels of injectants, such as coal, enable domestic integrated steel producers to minimize their dependence on coke.

Bethlehem decided to utilize the Simon Macawber Blast Furnace Granular Coal Injection (BFGCI) System which, unlike systems more widely employed that utilize only pulverized coal, is capable of injecting both granular and pulverized coal. We believe that the Simon Macawber system offers a variety of technical and economic advantages that make it potentially very attractive for application in the U.S. basic steel industry. A schematic showing the application of the technology to the blast furnace is given on Figure 5. Some of the advantages of this technology, which is being marketed in North America by ATSI/Simon Macawber include:

1. The injection system has been used overseas with granular coal as well as with pulverized coal. No other system has been utilized over this range of coal sizes.

2. The potential costs for granular coal systems are less than for pulverized.

3. Granular coal is easier to handle in pneumatic conveying systems. Granular coals are not as likely to stick to conveying pipes if moisture control is not adequately maintained.

4. Research tests conducted by British Steel indicate that granular coal is more easily maintained in the blast furnace raceway (combustion zone) and is less likely to pass through the coke bed. Coke replacement ratios obtained by British Steel have not been bettered in any worldwide installation.

5. Granular coal's coarseness delays gas evolution and temperature rise associated with coal combustion in the raceway. Consequently, it is less likely to generate high temperatures and gas flows at the furnace walls which result in high heat losses, more rapid refractory wear and poorer utilization of reducing gases.

6. System availability has exceeded 99 percent during several years of operation at British Steel.

7. High injection levels require accurate variable control of injection rates, both for individual tuyeres and the complete system. The unique variable speed, positive displacement Simon-Macawber injectors provide superior flow control and measurement over other coal injection systems.

With the full and successful implementation of this technology, the Burns Harbor plant has the potential of being self-sufficient in coke.

4.0 PROCESS DESCRIPTION

The coal preparation/injection facility will be retrofitted to blast furnaces, Units "C" and "D" at our Burns Harbor plant located in Porter County, Indiana, on the southeast shore of Lake Michigan (Figure 15). Highlights of the blast furnace and coal injection facilities are given on Figure 6. As noted on this Figure, Burns Harbor has experience with the injection of tar and oil as well as natural gas. This experience will be an asset when the coal injection trials begin.

A simplified flow diagram for the process is shown on Figure 7. The Raw Coal Handling Equipment and the Coal Preparation Facility includes the facilities and equipment utilized for the transportation and preparation of the coal from an existing railroad car dumper until it is prepared and stored prior to passage into the Coal Injection Facility; the Coal Injection Facility accepts the prepared coal and conveys it to the blast furnace tuyeres.

4.1 SITE LOCATION

The Coal Preparation Facility, the Coal Injection Facility and a utilities and control center for the facilities will be located in the process building and attached utilities building. The buildings are located between the two blast furnaces on a site previously occupied by a blast furnace warehouse and maintenance building. This location was chosen because it is the closest equidistant site to the two blast furnaces. Such location will minimize pressure drop and power requirements for transporting the coal to the blast furnaces.

4.2 RAW COAL HANDLING EQUIPMENT

Raw Coal Handling: Coal for this project will be transported by rail from coal mines to Burns Harbor similar to the way in which the plant now receives coal shipments for the coke ovens. The coal will be unloaded using an existing railroad car dumper which is currently part of the blast furnace material handling system. A modification to the current conveyor will be made to enable the coal to reach either the coke ovens or the coal pile for use at the Coal Preparation Facility.

This modification will require a new 60-inch wide transfer conveyor to be installed from the existing conveyor and run east about 186 feet (40 feet above the ground) to a junction house. There the coal will be transferred to a new 60-inch wide stockpile conveyor which will run 760 feet to the north and end at the space for the new raw coal storage pile. The coal pile will be formed using a 200-feet long radial stacker capable of building a 10-day storage pile (approximately 28,000 tons). The new material handling system from the car dumper to the coal storage pile will be sized at 2,300 tons per hour to match the output of the car dumper.

Raw Coal Reclaim: The raw coal reclaim tunnel will be installed underground beneath the coal storage pile. The concrete tunnel will be about 12 feet wide and 16 feet high and will contain four reclaim hoppers in the top of the tunnel. The reclaim hoppers, which are directly beneath the coal pile, will feed a 36-inch wide conveyor in the tunnel. The 400-feet long reclaim conveyor will transport the coal at a rate of 400 tons per hour above ground to the south of the storage pile. A magnetic separator will be located at the tail end of the conveyor to remove tramp ferrous metals. The conveyor will discharge the coal onto a vibrating screen which will separate coal over 2 inches in size from the main stream of minus 2 inch coal. The oversized coal will vary depending on the weather (more during the winter when frozen lumps are expected) and will pass through a precrusher which will discharge minus 2 inch coal. The coal from the precrusher will join the coal that passed through the screen and will be conveyed from ground level by a 36-inch wide plant feed conveyor to the top of the building that houses the Coal Preparation Facility.

The reclaiming of coal from the pile will be done by gravity as long as there is coal above each of the reclaim hoppers. It will be necessary to have a bulldozer on the pile to periodically push coal from the "dead" storage areas to the "live" storage areas above each of the reclaim hoppers.

4.3 COAL PREPARATION FACILITY

The plant feed conveyor will terminate about 103 feet high at the top of the process building that houses the Coal Preparation Facility. Coal will be transferred to a distribution conveyor which will enable the coal to be discharged into either of two steel raw coal storage silos. The raw coal silos will be cylindrical in shape with conical-shaped bottoms. They will be completely enclosed with a vent filter on top. Each silo will hold 240 tons of coal, which is a four-hour capacity at maximum injection levels. Air cannons will be located in the conical section to loosen the coal to assure that mass flow is attained through the silo.

Coal from each raw coal silo will flow into a feeder which controls the flow of coal to the coal preparation mill. In the preparation mill the coal will be ground to the desired particle size. Products of combustion from a natural gas fired burner will be mixed with recycled air from the downstream side of the process and will be swept through the mill grinding chamber. The air will lift the ground coal from the mill vertically through a classifier where oversized particles will be circulated back to the mill for further grinding. The proper sized particles will be carried away from the mill in a 52-inch pipe. During this transport phase, the coal will be dried to 1-1.5% moisture. The drying gas will be controlled to maintain oxygen levels below combustible levels. There will be two grinding mill systems. Each system will produce 30 tons per hour of pulverized coal or 60 tons per hour of granular coal.

The prepared coal will then be screened to remove any remaining oversize material. Below the screens, screw feeders will transport the product coal into one of four 180 ton product storage silos and will then be fed into a weigh hopper in two ton batches. The two ton batches will be dumped from the weigh hopper into the distribution bins which are part of the Coal Injection Facility.

4.4 COAL INJECTION FACILITY

The Coal Injection Facility will include four distribution bins located under the weigh hoppers described above. Each distribution bin contains 14 conical-shaped pant legs. Each pant leg will feed an injector which allows small amounts of coal to pass continually to an injection line. Inside the injection line, the coal will be mixed with high-pressure air and will be carried through approximately 600 feet of 1-1/2-inch pipe to an injection lance mounted on one of the 28 tuyere blowpipes at each furnace. At the injection lance tip, the coal will be mixed with the hot blast and will be carried into the furnace raceway. The fourteen injectors at the bottom of the distribution bin will feed alternate furnace tuyeres.

Each furnace requires two parallel series of equipment, each containing one product coal silo, one weigh hopper, one distribution bin, 14 injectors, 14 injection lines and 14 injection lances.

5.0 PROJECT DESCRIPTION

As shown on Figure 4, this project will obtain comparative data for a variety of coal types, grinds and injection level. The primary thrust of the work is to demonstrate (a) conversion for, (b) optimization of and (c) commercial performance characteristics of granular coal as a supplemental fuel for steel industry blast furnaces. The technology will be demonstrated on large, hard-driven blast furnaces using a wide range of coal types available in the U.S. The planned tests will assess the impact of coal particle size distribution as well as chemistry on the amount of coal that can be injected effectively. Upon successful completion of the work, the results will provide to others the information and confidence needed to assess the technical and economic advantages of applying the technology to their own facilities. The project will address a broad range of technical/economic issues as shown on Figure 8.

5.1 COAL GRIND SIZE

The facility has the potential to evaluate coal injection over a broader range of coal particle sizes than has ever been conducted at any plant in the U.S. Previously, only pulverized coal, defined as 70-80% minus 200 mesh (74 microns) has been injected commercially in the U.S. The primary focus of this project will be on granular coal, defined as 100% minus 4 mesh (5 mm), 98% minus 7 mesh (3 mm) and less than 30% minus 200 mesh (74 microns). The work will demonstrate on a commercial scale in the U.S. a system that can inject either granular or pulverized coal. More important, it will show the effects of domestic coal types on blast furnace performance. If the successful experiences of European operations with granular coal can be repeated or improved upon in the CCT III Project, then the advantages of granular coal over pulverized coal injection systems for commercial applications in the U.S. will have been demonstrated. These potential advantages include reduced capital cost for the grinding facilities and reduced consumption of electric energy (and other operating cost factors) for grinding the coal. The data to be generated on both fine and coarse injected coal will be of value in the planning of future U.S. commercial installations.

5.2 COAL INJECTION RATE

Operation over a range of coal rates will be evaluated by this project. We have targeted an injection level of 400 lbs of granular coal/NTHM. By operating and evaluating at coal injection rates, we will determine the technical limit for the coal injection system, establish the relationship between coal injection rate, furnace wall heat load, and any excessive wear of refractory lining to blast furnaces such as those at Burns Harbor; and confirm the operating costs and economic advantages that have been projected for coal injection.

5.3 COAL SOURCE

Our project will generate comparative data on coals with distinctly different chemical and physical characteristics. Plans call for using an Eastern bituminous coal with low ash and sulfur content; an Eastern bituminous coal with moderate ash and higher sulfur content; a Midwestern bituminous coal with higher inherent moisture but with low ash and moderate-to-high sulfur content; and a Western sub-bituminous coal with high inherent moisture but with low ash and sulfur content.

Each coal will be utilized for a sufficiently long period of time (about two months) to assess how it performs as a blast furnace injectant. Coal handling (i.e., grinding rates, injection system performance) and blast furnace parameters such as production, coke replacement, hot metal chemistry and slag volume are anticipated to be affected by the physical and chemical properties of the coal used for blast furnace coal injection. Data derived from this evaluation will make it possible for blast furnace operators to determine for themselves which coal would be most attractive for injection in their specific cases, including raw coal costs, transportation costs, coal grinding and injection costs, and the effects on blast furnace operations.

5.4 BLAST FURNACE CONVERSION METHOD

ither of the two blast furnaces at Burns Harbor is equipped with coal injection facilities. this project, we propose to convert both blast furnaces for coal injection during 1994. "C" urnace is scheduled to be out of service for an extended reline in mid-late 1994. It is during nis period that "C" Furnace will be fitted for coal injection. We propose to make the coal injection changes for "D" Furnace "on-the-fly", during very brief, monthly furnace outages. Thus, we will demonstrate the successful implementation of the modifications for blast furnace coal injection during both out-of-service and in-service modes. These will include planning and facilities for coal storage and handling, grinding, injection and alterations in the vicinity of the blast furnace itself (including work at the tuyeres).

Many of the physical components utilized in the coal injection system are also utilized in other commercial systems. The major portion of the technology envelope for this system is the integration of this equipment into a system that prepares coal as required for injection, allows flow to be controlled individually for each injection point into the blast furnace or allows all to be varied simultaneously, monitors the total amount injected and the flow to each tuyere, and includes the necessary know-how for injecting solid, granular fuel into a blast furnace. Key elements in this technology package are the weigh system, the variable flow injectors, lance sizing and positioning, and knowledge of how the factors of coal size, coal source and coal injection rate interact. Key elements of the portion of the project that pertain to blast furnace conversion methods involve the integration and coordination of engineering, construction and operations functions.

5.5 PROJECT SCOPE

As discussed earlier, the demonstration project is divided into three Phases with an overlap of Phases I and II as shown on the Project Schedule on Figure 9. During the period when project financing and environmenal permits were being obtained, the start of Phase II activities was deferred. However, work continued on Phase I resulting in a minimum of time lost through a shortened construction schedule.

At the present time, a turnkey contract has been awarded to Fluor Daniel for the facility. Design Engineering is nearing completion. Equipment purchase orders have been placed with ATSI/Simon Macawber for the injection systems and construction is in progress. Regarding blast furnace improvements, those upgrades scheduled for the D furnace were completed during the last reline in late 1991. Planned major improvements to the C furnace will be completed during the reline of that furnace in the summer/fall 1994. The coal injection system is scheduled to be completed early in 1995 with testing to begin shortly thereafter.

6.0 PROJECT INITIATION THROUGH FIRST QUARTER ACCOMPLISHMENTS

During the period, significant progress was made in firming the estimated cost of the coal preparation and injection facility as well as the planned improvements to the blast furnaces. Coal grinding trials were made using the proposed tests coals. Work progressed on outlining the environmental monitoring plan, completing the Environmental Assessment and proceeding to obtain the necessary permits.

Meetings were held with British Steel Consultants and ATSI/Simon Macawber to finalize the required licensing agreements. Numerous meetings were also held at the plant site and with potential sub contractors and major equipment suppliers to insure smooth project implementation when construction begins.

A Phase I review meeting among DOE, Fluor Daniel, ATSI, Simon Macawber and Bethlehem was held on February 9 & 10, 1993 at the offices of Fluor Daniel in Greenville, S.C.

7.0 SECOND QUARTER ACCOMPLISHMENTS

The April-June 1993 period was the culmination of numerous administrative requirements of the project that had to be completed before construction could begin. A Cost Reasonableness Review of the GCI facility was completed at the office of Fluor Daniel on April 6, 1993. DOE advised that the request to enter Budget Period 2 (Phase II) of the project had been approved on April 26, 1993. A permit to construct the GCI facility was approved by the State of Indiana[5]. An Environmental Assessment was approved by DOE[4].

8.0 THIRD QUARTER ACCOMPLISHMENTS

Groundbreaking for the project occurred near the end of the July-September 1993 period. A report on the first portion of the Hazardous Operation Analysis of the GCI facility was submitted to DOE on July 14, 1993. A visit was made on July 28, 1993 to the Scunthorpe Works of British Steel to observe and discuss their Granular Coal Injection System. A visit was also made to the offices and plant of Simon Macawber on July 29, 1993 to discuss the equipment SM provided to British Steel for their Scunthorpe and Ravenscraig Works.

A construction permit for the GCI facility was obtained August 4, 1993 and an EPC contract with Fluor Daniel for the GCI facility was signed on August 27, 1993. Financing of Bethlehem's portion of the project was finalized on September 1, 1993. A paper on this project was presented at the Second Annual Clean Coal Technology Conference, September 8, 1993 in Atlanta, Georgia[3].

9.0 FOURTH QUARTER ACCOMPLISHMENTS

During the final quarter of 1993, construction continued at a rapid pace. The setting of injection system distribution bins and weigh bins was completed ahead of schedule. Engineering concentrated on expediting supplier design information and placement of remaining equipment purchase orders. ATSI-Simon Macawber and Williams Patent Crusher & Pulverizer Company designs were modeled and interference checks run for coordination. All major equipment orders were placed.

A HAZOP's review was conducted for Segment II, Grinding and Drying, and Segment III, Gravity Feed of Coal through Screens. Stockhouse improvements planned for C furnace, including changes recommended by British Steel Consultants, were reviewed by Engineering and Plant Operations.

10.0 PROJECT STATUS

Status of the project at the end of December 1993 is summarized below:

10.1 ENGINEERING STATUS

Process Design Engineering is essentially complete. Construction Engineering for the Coal Preparation and Injection System, Engineering is 54% complete versus the plan of 54%. Engineering concentrated on expediting supplier design information and placement of remaining equipment purchase orders. Work continues on stockhouse and cooling improvements to the "C" Furnace during its upcoming reline scheduled for mid-late 1994.

Procurement activities are proceeding within budget and on schedule. Emphasis continues on placement of balance of purchase orders to expedite the flow of vendor documents to support engineering. Jobsite visit was made and overall material management plan was developed and implemented for all field required bulk material purchases.

Request For Quotations To Be Issued:	55	
Request For Quotations Issued To Date:	44	80 percent complete
Purchase Orders To Be Issued:	58	
Purchase Orders Issued To Date:	31	53 percent complete
Subcontract Packages To Be Issued:	17	
Subcontract Packages Issued To Date:	12	70 percent complete
Request for Quotations Issued To Date:	44	80 percent complete
Engineered Equipment Purchased:		94 percent complete
Engineered Equipment Received at Job Site:		14 percent complete

Major material for the "C" furnace reline has been ordered for shipment during 1Q94.

10.2 CONSTRUCTION STATUS

For the Coal Preparation and Injection System, construction is 15% complete against an early start plan of 15% and a late start plan of 9%. A slight variance from the early start plan was primarily due to concrete placement which was impacted by the onset of colder weather and rebar misfabrication. (Figures 16, 17)

Civil and earthwork is 42% complete. Excavation and backfill continue on the Utility Pipe Bridge foundations, Fire Protection, DIW, Lake Water, Natural Gas and Plant Air systems. Excavation for the blast furnace "C" pipe bridge foundations began.

Concrete is 47% complete with approximately 3,770 cubic yards of concrete placed. Process Structure and Utility Pipe Bridge foundations and Coal Reclaim Tunnel walls were completed. The Process Structure equipment foundations were begun. Utility Building foundations and Coal Reclaim Tunnel roof slabs continue. (Figures 18, 19)

Structural steel is 9% complete with approximately 278 tons of steel erected in the Process structure steel to Elevation 659. The Utility pipe bridge structural steel has been received and pre-assembly has begun. (Figure 20)

Equipment is 10% complete. All four distribution bins and all four weigh bins have been set in place in the Process Structure. Fabrication of all four product coal silos was completed and two have been internally coated.

Piping is 5% complete. Installation of underground Natural Gas, Plant Air systems and transformer drain piping was completed. Underground DIW, Fire Protection and Lake Water installation continue. Piping is complete on the existing Utility Pipe bridge with exception of system tie-ins.

Electrical is 6% complete. Installation of underground electrical in the Process Structure and Utility Building and grounding at pipe bridge foundations, conveyor foundations and equipment foundations continues.

11.0 REFERENCES

1. D. S. Gathergood, "Coal Injection Into the Blast Furnace", International Iron & Steel Institute Committee on Technology, April 26, 1988.

2. D. S. Gathergood and G. Cooper, "Blast Furnace Injection - Why Granular Coal"? Steel Technology International, 1988.

3. D. Kwasnoski and L. L. Walter, "Blast Furnace Granular Coal Injection", Second Annual Clean Coal Technology Conference, Atlanta, GA, September 8, 1993.

4. J. S. Siegel, Environmental Assessment Approval, May 6, 1993.

5. P. Dubenetzky, "Construction Permit, Office of Air Management, Indiana Department of Environmental Management", issued August 4, 1993.

FIGURE 1

THE STEELMAKING PROCESS

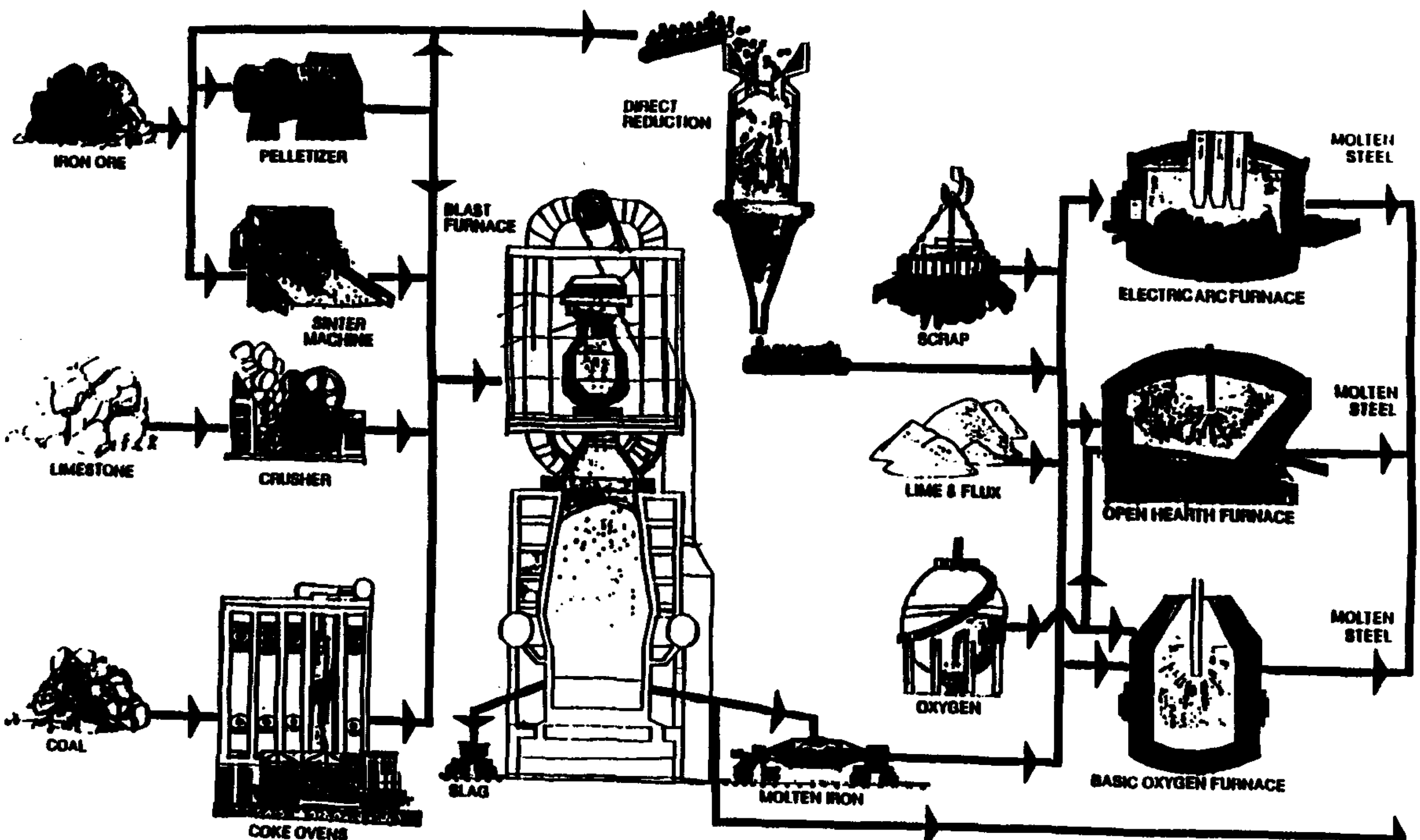


FIGURE 2

THE BLAST FURNACE COMPLEX

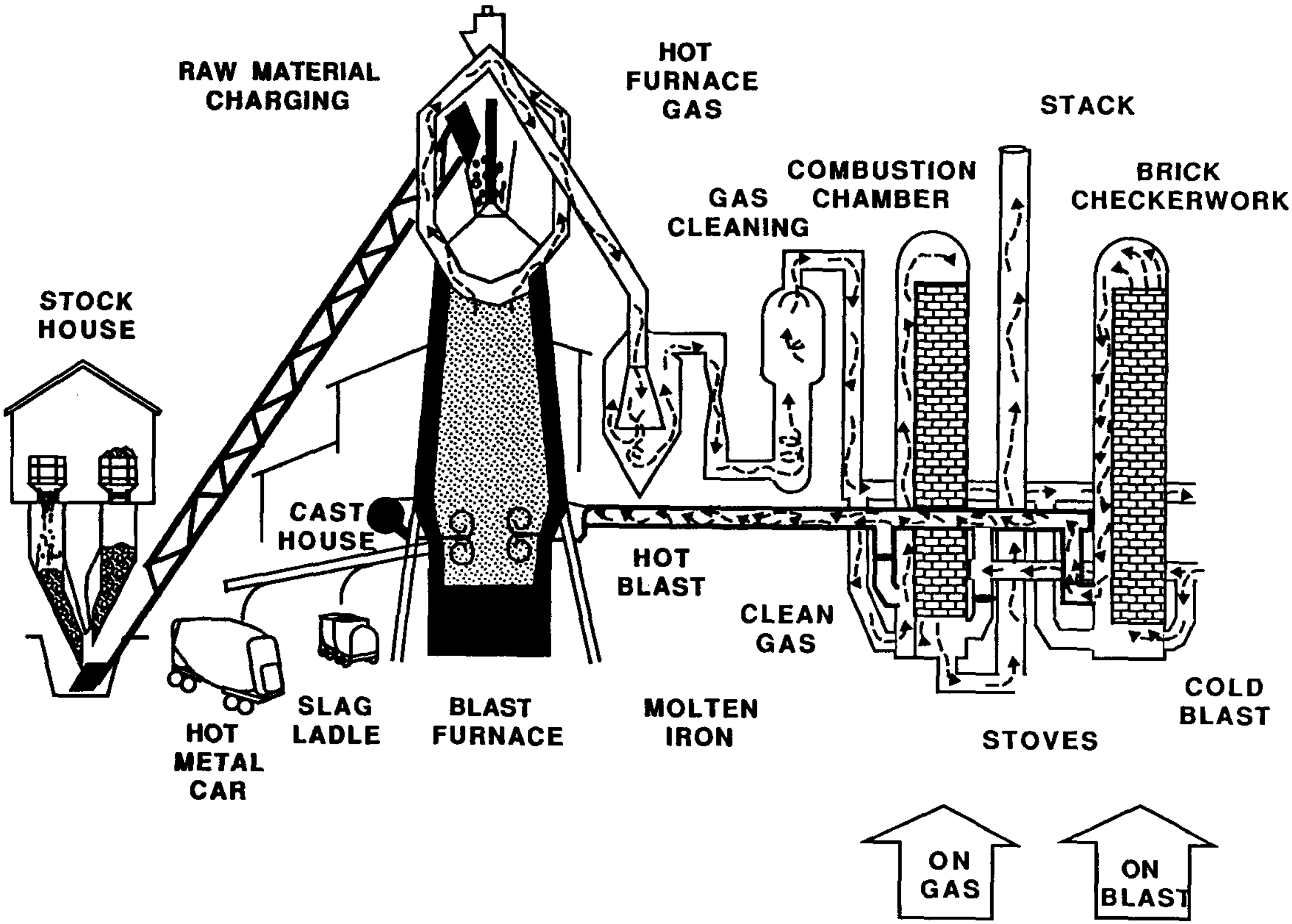


FIGURE 3

ZONES IN THE BLAST FURNACE

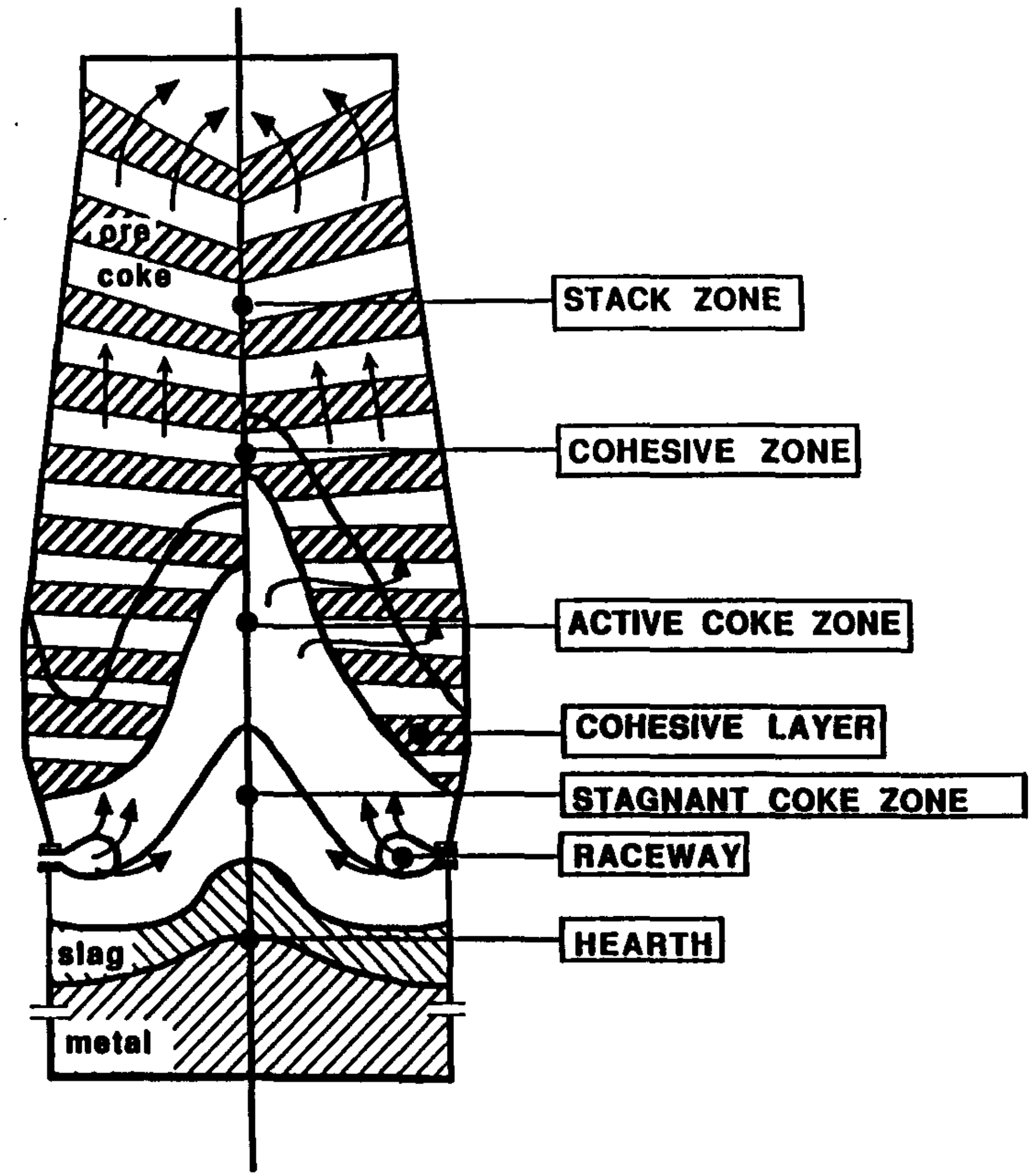


FIGURE 4

Coal Injection Test Program Parameters

Coal Grind Size	-	Granular (100% -4 mesh) to Pulverized (75% -200 mesh)
Injection Level	-	Up to 400 lbs per NTHM
Coal Types	-	East, Midwest and West (Differing Chemical and Physical Characteristics)
System Installation	-	During Furnace Reline and "On-the-Fly"
Reduced Coke Requirement	-	Less Reliance on Foreign Coke and/or Environmental Problems Associated with Domestic Coke Production

FIGURE 5

APPLICATION OF COAL INJECTION

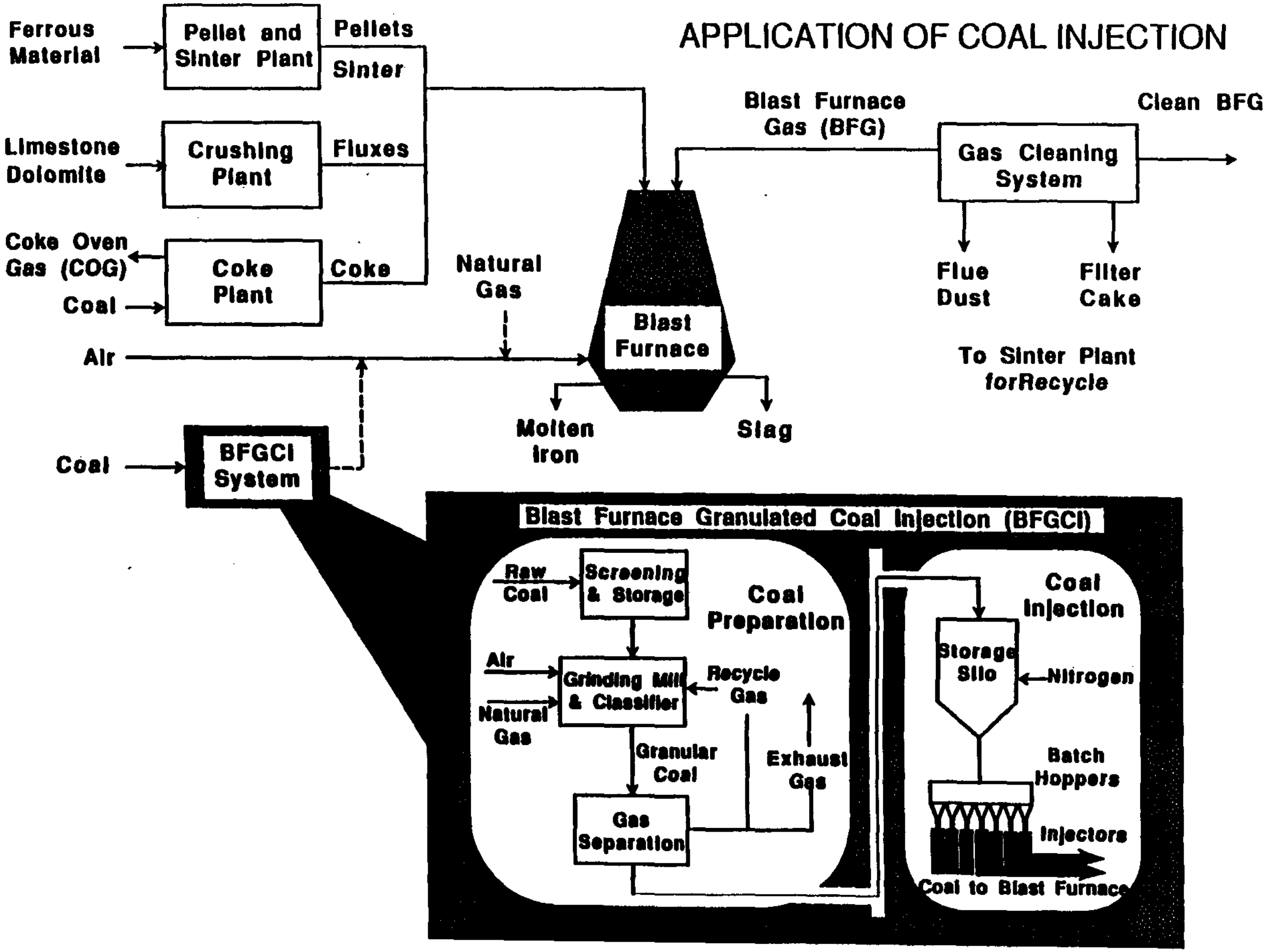


FIGURE 6

Coal Injection Test Site/Facilities

Location	-	Bethlehem Steel Burns Harbor Plant, Porter County, Northern Indiana
Blast Furnaces		
- Number	-	2
- Size	-	35 & 38 ft. Hearth Diameter
- Production Rate	-	Approximately 7,000 tons/Day Pig Iron/Furnace (8 TPD per 100 cu.ft. Working Volume)
- Fuel Injection	-	Natural Gas, Oil, Tar
Coal Injection Facilities	-	Simon-Macawber

FIGURE 7

COAL INJECTION - BURNS HARBOR PLANT

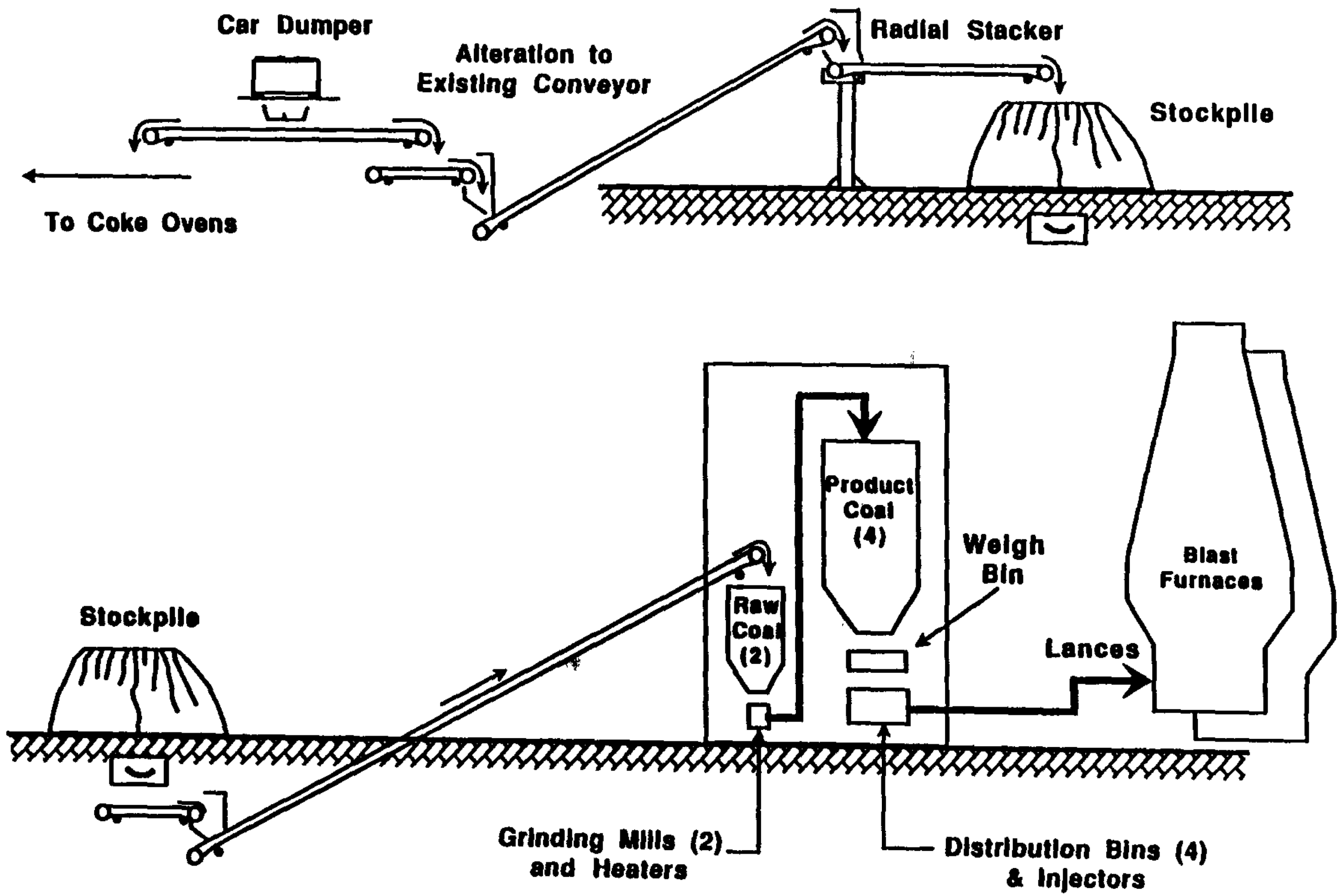


FIGURE 8

Coal Injection Test Program Goals

Coal Grind Size	-	Granular (100% -4 mesh) to Pulverized (75% -200 mesh)
Injection Level	-	Up to 400 lbs per NTHM
Coal Types	-	East, Midwest and West (Differing Chemical and Physical Characteristics)
System Installation	-	During Furnace Reline and "On-the-Fly"

FIGURE 9

PROJECT SCHEDULE

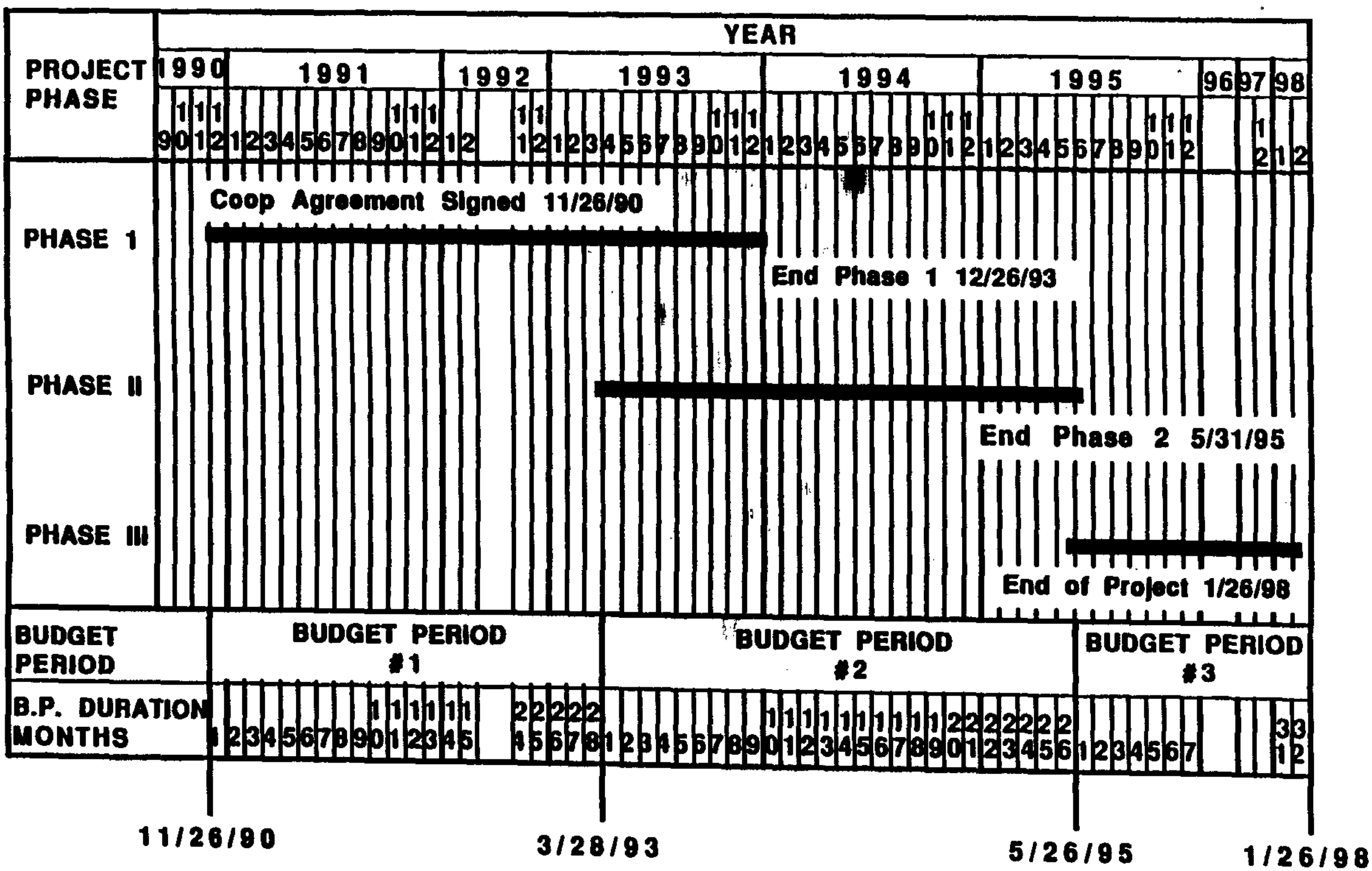


FIGURE 10

Project Milestone Schedule

Begin Detailed Construction Engineering	April 1, 1993
Received State Environmental Construction Permit	August 4, 1993
Start Construction	August 31, 1993
90% Design Review	January 12, 1994
50% Construction Review	June 1994
100% Construction Review	December 1994
Begin Coal Testing Demonstration	May 1995
Complete Coal Testing Demonstration	January 1998

FIGURE 11

Project Summary Cost Estimate

The estimated project cost is summarized into Pre-award, Phase I (Design), Phase II (Procurement & Construction), and Phase III (Operation, Data Collection, Reporting) as follows:

Pre-award	$90,000	
Phase I	$5,100,000	
Phase II	$133,850,000	
Phase III	$51,610,000	
	$190,650,000	Total Project Cost

The total project cost is shared between Bethlehem Steel and the DOE as follows:

DOE Share............................	$31,259,530	16.4%
Bethlehem Steel Share..........	$159,390,470	83.6%

FIGURE 12

Phase I & II Organization

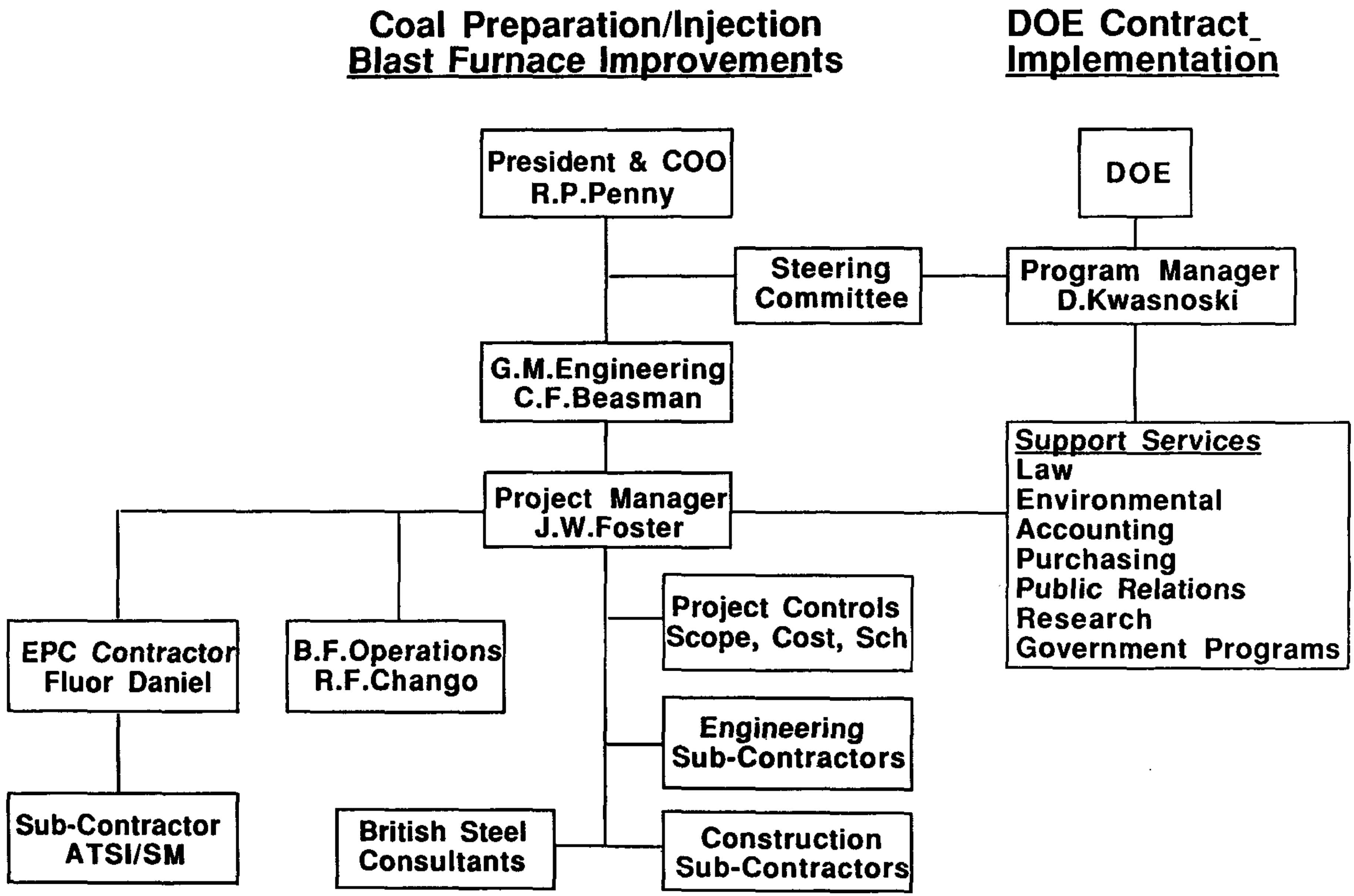


FIGURE 13
Phase III Organization

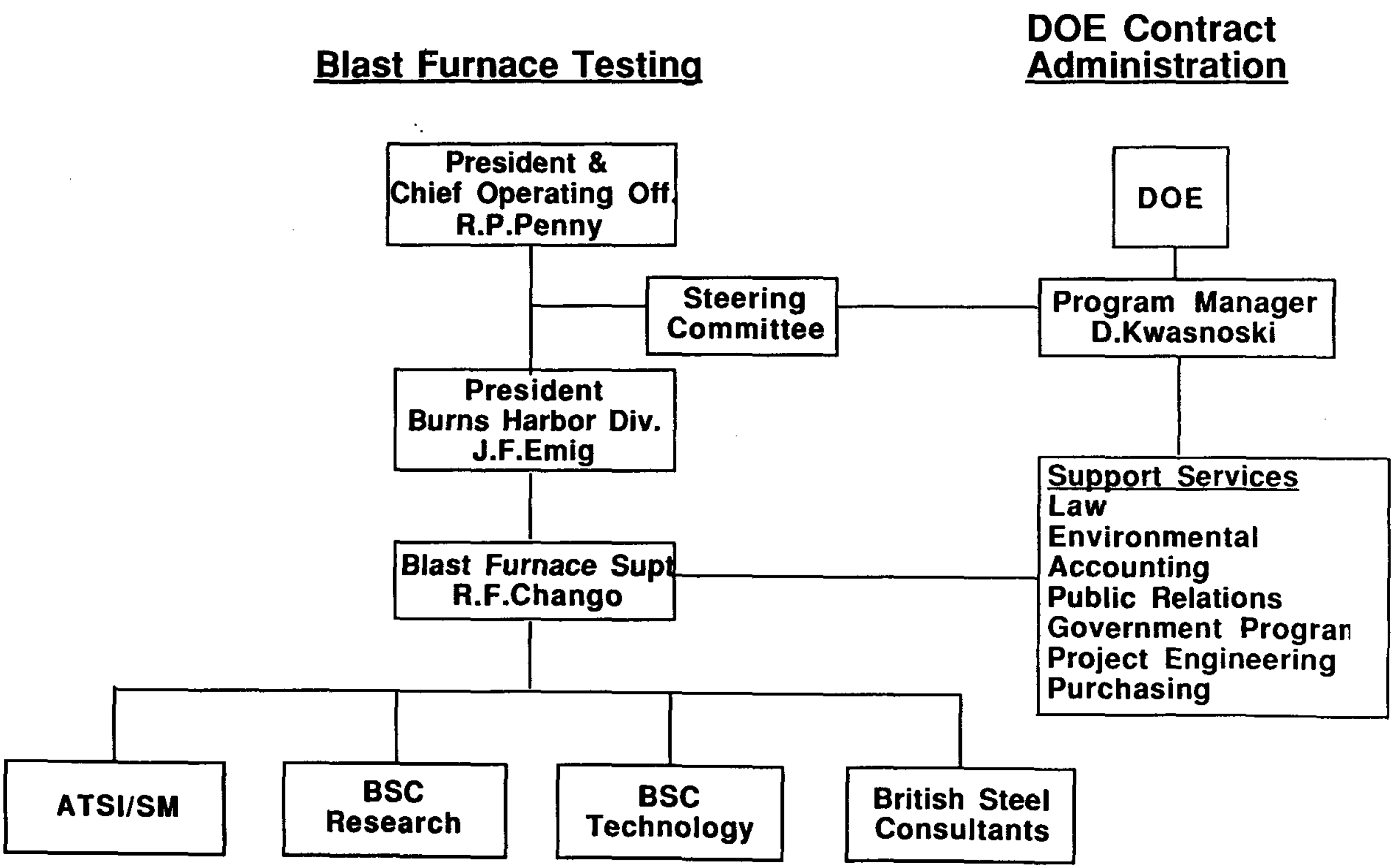
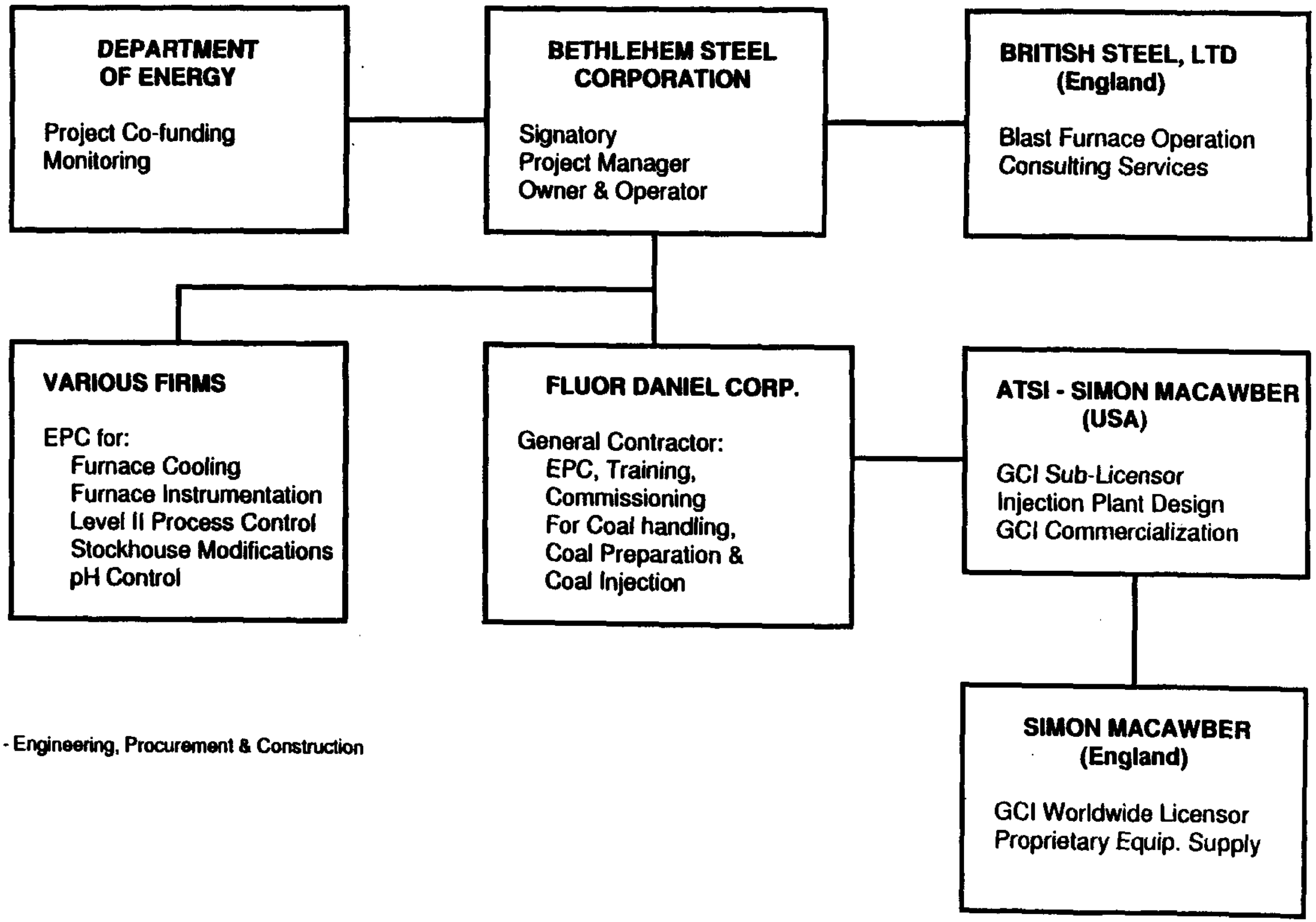
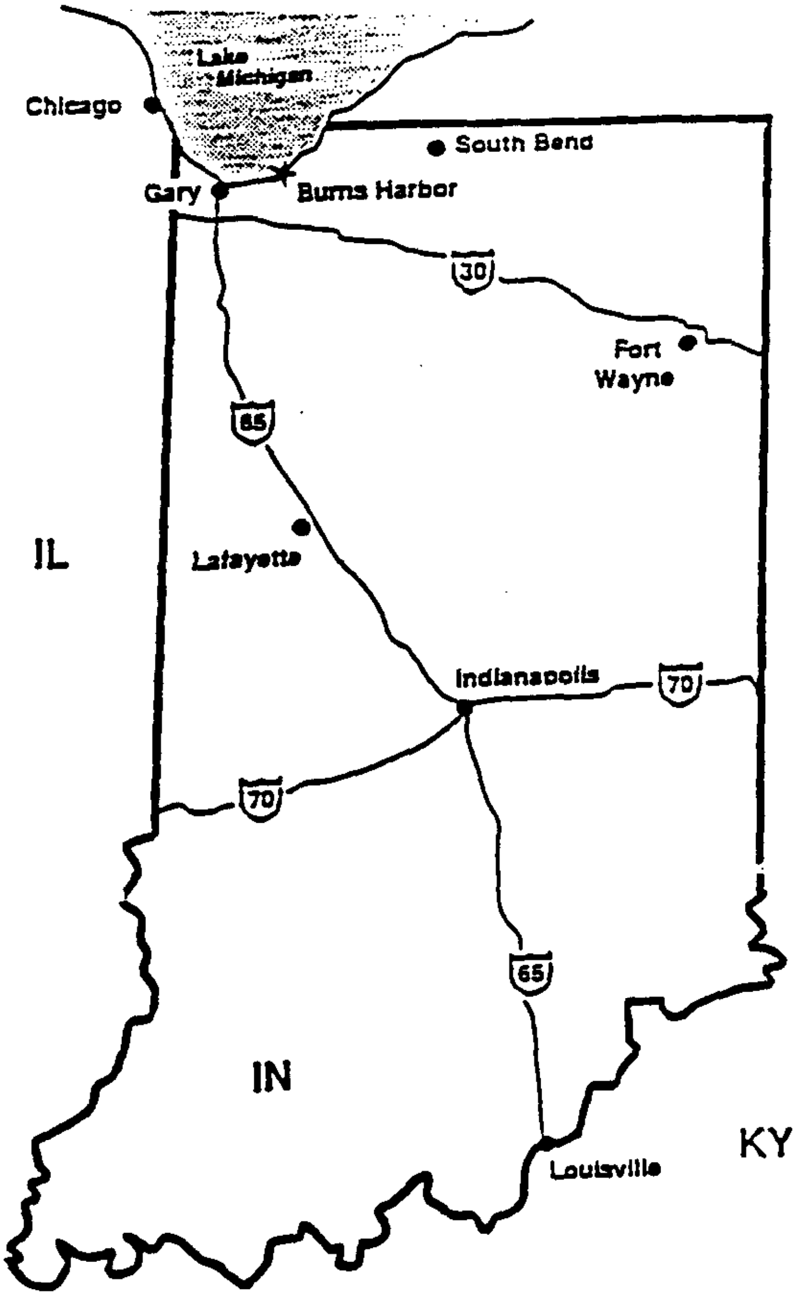


FIGURE 14

PROJECT CONSTRUCTION ORGANIZATION

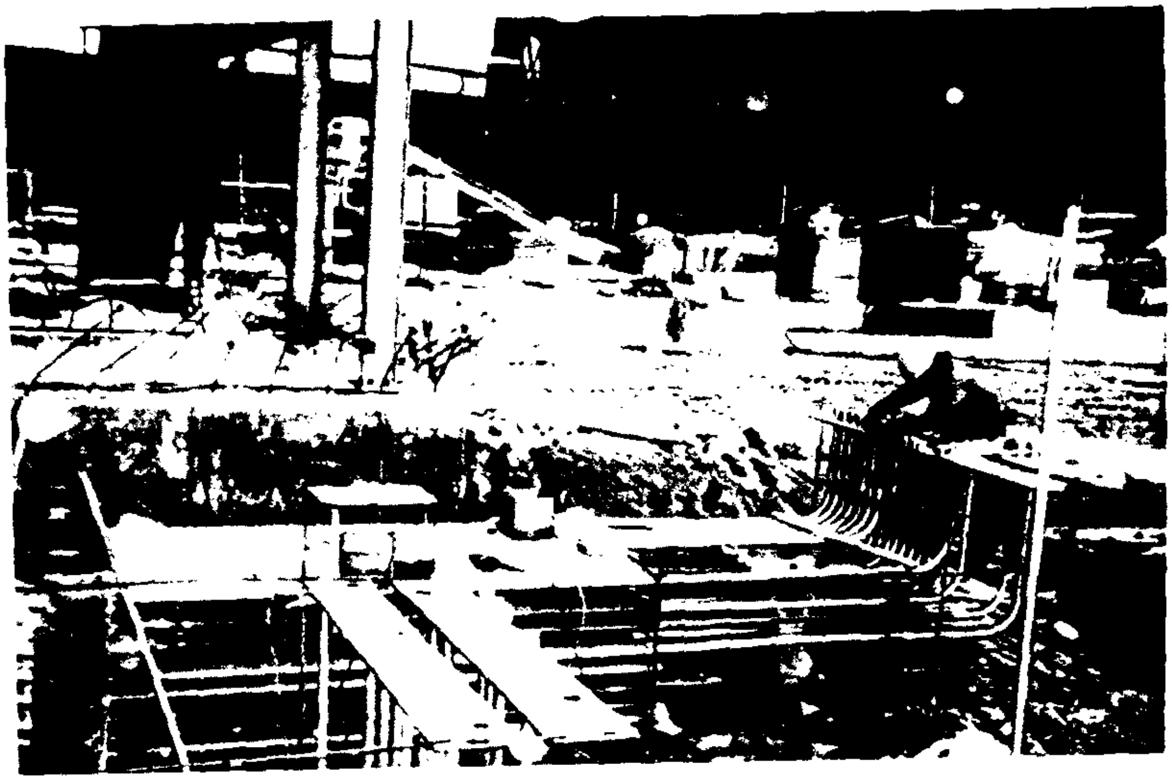


EPC - Engineering, Procurement & Construction



Bethlehem Steel BFGCI Project

FIGURE 15

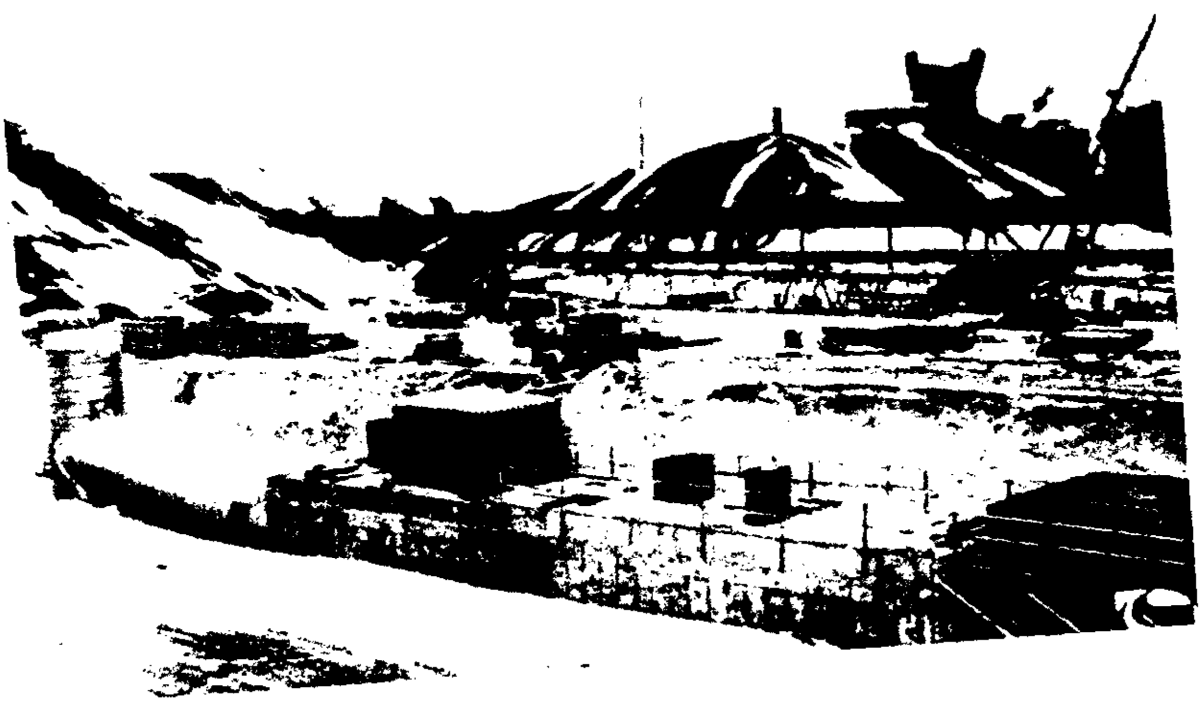


Utility Building - Conduit to Injectors

FIGURE 16

Process Structure - Underfloor Conduit for Injectors

FIGURE 17

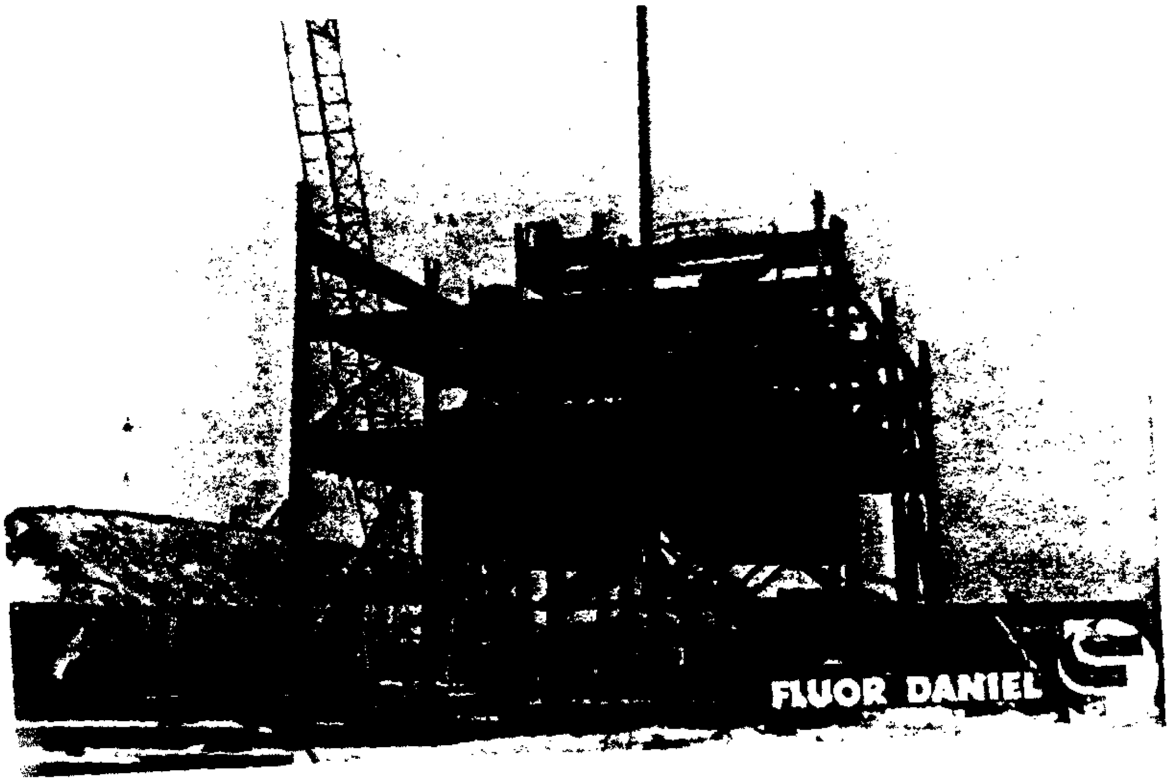


Coal Reclaim Tunnel Looking Northeast

FIGURE 18

Coal Reclaim Tunnel Looking North

FIGURE 19



Process Structure/Utility Building Looking Northwest

FIGURE 20