ORIGINAL

BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

In Re: Petition on behalf of Citizens of the State of Florida to require Progress Energy Florida, Inc. to refund customers $143 million	)))))	DOCKET NO. 060658-EI March 6, 2007

REBUTTAL TESTIMONY OF
JOSEPH A. BARSIN

Harold McLean
Public Counsel

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Room 812
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Attorney for the Citizens
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REBUTTAL TESTIMONY OF JOSEPH BARSIN

ON BEHALF OF CITIZENS OF THE STATE OF FLORIDA

Q. Please state your name and your business address.

A. My name is Joseph A. Barsin. My address is 5500 Five Knolls Drive, Charlotte, NC 28226.

Q. By whom are you employed?

A. I am President and the principal of Technocrats, Inc., a consulting engineering firm.

Q. For whom do you appear in this proceeding?

A. I am testifying on behalf of the Florida Office of Public Counsel, representing the Citizens of the State of Florida.

Q. Please describe your educational background and professional experience.

A. I hold a BS in Marine Engineering degree awarded in 1964 from the State University of New York Maritime College located at Fort Schuyler, New York. I hold a MDP from Northeastern University awarded in 1985. I have held US Coast Guard Licenses as a 3rd Assistant Engineer for Steam or Diesel, any size vessel oceans unlimited. I am a FELLOW of the American Society of Mechanical Engineers, an awardee of the George Westinghouse Silver Medal for eminent achievements in the field of mechanical engineering, and most recently the 2005 awardee of the Beloit Prize issued by the Technical Association of Pulp and Paper Industries for technical excellence. Prior to my consulting practice I worked with Babcock & Wilcox for 28 years. While with Babcock & Wilcox I held positions of ever increasing responsibility, starting in Field Engineering. I became Manager of Combustion Systems. In that capacity my responsibilities included evaluating specific coals and the associated ash effects to set slagging and fouling indexes (which in turn set the minimum size of the furnace), evaluating all fuels (including coal), sizing equipment such as burners, designing pulverizer systems, determining the number, location and design of deslagging devices such as sootblowers applied, and approving the guarantees associated with the achievement of any Maximum Continuous Rating (MCR) with a specific design fuel. I retired from a Babcock & Wilcox subsidiary, Diamond Power International, as General Manager Boiler Cleaning Equipment –this is the company that designed and manufactured deslagging devices such as sootblowers, water blowers and water cannons.

I have attached as Exhibit __ (JAB-1) a more detailed resume' of my professional experience.

Q. What is the purpose of your testimony?

A. In my testimony, I will rebut certain assertions by PEF witnesses Rod Hatt, Clifford Toms, Sasha Weintraub, and J. N. Heller.

Q. Please summarize the principal points of your rebuttal testimony.

A. In my rebuttal testimony I will develop and prove the following points:

- PEF witnesses Hatt and Toms are mistaken when they assert, without any factual support, that PEF would have lost 124 megawatts of capacity had PEF burned a 50/50 blend of Powder River Basin subbituminous and Eastern bituminous coals in Crystal River Units 4 and 5 during the period 1996-2005. Mr. Hatt, in particular, begins with a recitation of the combustion properties of PRB coal and leaps immediately to the conclusion that the boilers would not be capable of generating at this level on a sustained basis. Incredibly, his "seam to stack" analysis omits any recognition of, much less consideration of, the unit operating capabilities that were specified by Florida Power Corporation, designed and contracted for by the designers of the units, and built into and *guaranteed* by the vendors. From the outset, PEF's predecessor, Florida Power Corporation specified, and the CR4 and CR5 units were engineered, designed, and constructed, to produce the same maximum number of megawatts on a sustained basis when burning a 50/50 blend of Powder River Basin (PRB) subbituminous and Eastern bituminous coals as the utility produced during 1996-2005 when burning bituminous coal. In fact, Babcock & Wilcox, the manufacturer of the boilers for CR4 and CR5, *guaranteed* that the boilers would deliver to the turbine generator the steam quantities and steam pressures necessary to operate at the same maximum steam overpressure condition noted by PEF's witnesses, with no limitation on the number of hours the units could be called on to produce at this level. This guarantee, enforceable by Florida Power Corporation, went beyond the usual industry practice and explains, in part, why the boilers of CR4 and CR5 were so massively and conservatively designed. It is only because PEF's predecessor, Florida Power Corporation, elected to test perform CR4 and CR5 with bituminous coal rather than the 50/50 blend that was the subject of the guarantee that Mr. Hatt can even speculate about the units' capabilities.

- Because the assumption of a difference in megawatts of output between the 50/50 PRB/bituminous blend scenario and the 100% bituminous scenario provided to him by Mr. Hatt and Mr. Toms was fallacious, PEF witness Crisp's calculation of replacement power costs to be associated with operations of CR4 and CR5 based on burning a 50/50 blend of Powder River Basin subbituminous and Eastern bituminous coals is entirely bogus. As the units were specified, designed, constructed, and *guaranteed* to operate at the same maximum rating claimed by PEF for the all-bituminous scenario, without limitation as to the number of hours, the differential of the output of CR4 and CR5 between the 50/50 PRB/bituminous and all-bituminous scenarios is zero.
- PEF witnesses Mr. Hatt and Mr. Wayne Toms are mistaken when they assert, without factual basis, that a seventh pulverizer would have been necessary to enable each of CR4 and CR5 to produce the same output when burning the 50/50 blend of PRB and bituminous coals that PEF produced from these units with 100% bituminous coal. Mr. Hatt appears to have observed a spot left for the addition of a seventh pulverizer for each unit and to have leaped to the conclusion that the seventh pulverizer was essential to the operation of the units at high output, without recognition of, much less consideration of, the design capacity of each pulverizer. The information was readily available in contract documents and design manuals maintained by PEF, which I have reviewed. Each unit was designed, constructed, and *guaranteed* by Babcock & Wilcox to generate the same level of maximum output that PEF experienced with 100% bituminous coal when burning the 50/50 PRB/bituminous blend and operating with the *six*

pulverizers supplied by Babcock & Wilcox under its contract with PEF's predecessor. In fact, Babcock & Wilcox designed the boilers to be capable of generating this high, maximum output level using the 50/50 blend when only *five* of the six installed pulverizers were operational.

- Mr. Hatt is mistaken when he asserts that little was known about the slagging and fouling properties of PRB subbituminous coal at the time CR4 and CR5 were designed. He is therefore mistaken when he asserts, based on this false premise, that the boilers of CR4 and CR5 would need to be modified before the boilers could be expected to burn PRB coal successfully. I know, because I was involved in both the research of PRB coal properties and their impact on boilers prior to the design of CR4 and CR5, as well as the actual designing of these units. The properties of PRB coal were well known and understood when CR4 and CR5 were designed, as were the design parameters needed to anticipate and accommodate those properties and burn PRB coal successfully. Severe slagging and fouling coals can be and are burned successfully in boilers that are sized, configured, and designed to burn them. All design considerations and parameters necessary to address the slagging and fouling tendencies of PRB coal were incorporated in the design and construction of CR4 and CR5. In fact, Babcock & Wilcox *guaranteed* that the boilers would burn the 50/50 blend of PRB and bituminous coals without interference from slagging or fouling.

- Mr. Hatt is mistaken when he asserts that PEF would need to purchase expensive new equipment with which to blend PRB coal and bituminous coal on site. In his testimony, Mr. Hatt omits any reference to the existing components and systems that answer fully his questioning of the ability of the existing mechanisms to blend coals successfully. At the outset of the project, PEF's predecessor, Florida Power Corporation, directed Black and Veatch, who provided the design and engineering services for CR4 and CR5, to provide for on-site blending of two different coals. Black and Veatch provided a system of equipment and storage areas for blending that is flexible, redundant, and fully capable of providing the blending function. The existing system needs only modest and inexpensive enhancements to provide washdown capabilities. The cost of such improvements is insignificant. On the other hand, to throw away equipment that was well designed for the purpose and replace it unnecessarily would be wasteful and imprudent in the extreme.

- Mr. Hatt is mistaken when he asserts, without factual basis, that the precipitators of CR4 and CR5 would need to be modified before the units could burn the 50/50 blend successfully. Again, Mr. Hatt begins with the properties of PRB coal and leaps to the conclusion that the existing precipitators are inadequate, without any recognition, much less consideration of, the capabilities that were designed and built into the existing precipitators. Those design parameters and capabilities are readily available in contract documents and design manuals maintained by PEF. Again, Mr. Hatt's testimony begins with the faulty premise that the properties and chemistry of PRB coal were not understood when the precipitators were designed. The properties of PRB coal were understood well at the time the precipitators were designed, as were the precipitator design parameters (size, configuration, design) needed to deal with them. The precipitators were designed, constructed, and *guaranteed* to be able to remove particulate from the stack emissions sufficiently well to meet the emission standards applicable to CR4 and CR5 when burning the 50/50 PRB/bituminous blend of coals. It is only because PEF's predecessor elected to test perform the units with bituminous coal rather than the 50/50 blend that Mr. Hatt can even speculate about the precipitators' performance.

• Mr. Hatt is demonstrably mistaken when he speculates that the existing coal conveyors may not be adequate to deliver the quantities of the 50/50 PRB/bituminous blend of coals to the boilers that would be necessary to sustain generation at the same level of maximum output that PEF experienced with 100% bituminous coal. As with all other design parameters, Black and Veatch started with the assumption that CR4 and CR5 would be burning the 50/50 blend of coals, and specified the capacity and speed of the coal handling and conveying equipment accordingly. When one traces through the technical capabilities and relates them to requirements for maximum output, it becomes evident that the existing coal handling and conveying systems are more than adequate to support the same levels of maximum output when burning the 50/50 PRB/bituminous blend that PEF experienced with 100% bituminous coal.

• Mr. Hatt is mistaken when he asserts that CR4 andCR5 were not built with dust control, fire suppression, and other safety measures. I have studied the design details for CR4 and CR5, and I recently inspected the units. Black and Veatch's written design standards specified elaborate dust control and fire suppression measures that clearly were based on the assumption that PEF would be burning the 50/50 PRB/bituminous blend. Upon inspection, it is obvious that all of those systems were installed. It is equally obvious that over time PEF has removed many of the systems, and has allowed many others to deteriorate to a state of disrepair. While dust control, fire suppression, and housekeeping measures therefore would need to be provided now, in many instances the items needed would be replacements of those that were specified, designed, and constructed when the units were new. In any event, the costs of such measures are insignificant in relation to the fuel savings identified by OPC witness Robert Sansom. More importantly to this case, there would have been little need for any expenditures if PEF had maintained the original equipment and shifted to the 50/50 PRB/bituminous blend in 1996 with those original systems intact.

- In my review of the testimony, contract documents and actual designs applied that together serve to define CR4 and CR5, it is evident that the entire plant was permitted, specified, designed and constructed to generate 5,239,600 pounds of 1000F / 1000F steam at 2640 psi burning a 50/50 CAPP/PRB fuel containing 10,285 BTUs/pound, which in this plant with the turbine provided results in a gross generation of 770 MW -- and sustain this design loading 24 hours per day, seven days per week. The fuel supply system was designed to support the burn rate of 330 tons per hour of the specified fuel blend to insure 100% redundancy was provided.

Q. Please describe how you have organized your testimony.

A. To evaluate the testimony of PEF's witnesses, it is necessary to understand the manner in which the utility's choice of fuels impacts the design and construction of the power plant in which the fuel will be burned. To provide context for my comments, I will begin with a brief overview of the manner in which major power plants, such as CR4 and CR5, are specified, designed, and built. In this overview, I will identify and define several terms that will appear later in my testimony. I will then identify the statements by the PEF witnesses to which my testimony is directed, and respond to those statements.

OVERVIEW OF DESIGN AND CONTRACT PROCESSES

Q. Beginning with the overview, describe the process through which a utility and contracting vendors specify, design, and construct a major power plant project.

A. The process begins when the Utility projects future growth, reserve margins, asset retirements and projects a need for additional generation capacity. The decision is made to build a new power plant. The utility will write a general RFP (Request for Proposal) describing approximate size, location, specific fuel(s), and approximate date of operation to Architect Engineer (AE) firms with expertise in the area.

Q. What happens when the AE is selected?

A. Eventually one AE is selected and the contract is finalized. See Exhibit _____ (JAB 4) Agreement for Engineering Services for Crystal River #4. The contract contains a general project statement constructed from the PEF RFP and the numerous clarifications issued during the negotiations of the contract.

The project manager will delegate engineering for specific design/specification creation to those departments within the AEs firm with the proper expertise, for Steam Generators, Coal Handling, Controls, Turbine Generator etc. The AE team immediately goes into the project and starts engineering and creating the associated detail specifications for the plant. The most critical specification in this case is the Boiler Specification. That document contains the desired stream flow, final steam temperatures, design basis fuel, alternative fuels, emission limits, and other details including schedules and in this specific construction was to be included. Once these specifications are created, reviewed by Black and Veatch management and approved they then are released to PEF for their approval and once that is received the specifications are released to the steam generator potential suppliers.

Q. What happens when the steam generator vendors receive the RFPs?

A. Proposal level engineering is initiated and since the boiler suppliers have been working informally with the AEs for several months on this potential project much of the early work has been completed. The design zeros in on the specified design fuel, and the require output at the specified maximum continuous rating.

Q. How important to the design process is the specified fuel?

A. The design basis fuel along with the maximum continuous rating (MCR) rating is the entire basis for the detailed design and the proposal. The design basis fuel is evaluated using experience with similar fuels, or, if unique, by creating laboratory samples and creating ashes so that the ash performace can be evaluated. Once evaluated, the ash resulting from a specified fuel or a blended fuel similar to that specified would be compared to other ashes within which the vendor had actual field experience and the performance of which it had been able to evaluate. The vendor would then index the fuel slagging and fouling potential.

Q. What do you mean by indexing?

A. Through experience, categories have been developed into which coals fall based on characteristics of combustion ash, and the propensity of that ash to form slag or create problems of fouling. Also through experience, design criteria have been developed which address the means that can be employed to accommodate and neutralize the slagging and fouling potential of each category. In other words, as soon as the AE accurately indexes a particular coal, the design criteria applicable to that index are invoked.

Once set, the index would dictate the entire steam generator required box size. The ash index impacts every major piece of equipment: Furnace box size, number of burners, number of pulverizers, Furnace Exit Gas Temperature (FEGT), clear side spacing (CSS), in the convection gas path, the number and location of sootblowers, and gas side permitted velocities. The fuel is the most critical component to understand as completely as possible to correctly design a heat transfer machine that is specified, as in the case of CR4 and CR5, to be capable of running 100% of the time at a specified MCR. See Exhibit __ (JAB 5), "Boiler Design Considerations."

Q. How important to the design is the specified steam flow?

A. This specification is as important to the design as the fuel. The specification for CR4 and CR5 directed that there be a performance point at FULL LOAD (Turbine Name Plate) and at the MAXIMUM CONTUNIOUS LOAD (MCR). MCR was defined as turbine valves wide open with 5% overpressure steam provided by the steam generator. The required heat input to design for would be the "that maximum" that is MCR point and all heat exchange equipment would have to meet that requirement as well as satisfy the fuel ash indexes.

Once the fuel and MCR were known and classified, the detail design could then commence. It is an iterative process composed of getting enough heat transfer surface in the steam generator to make the heat balance required at the specified MCR without violating the fuel ash indexes. "Full Load" performance would be achieved using the operational tools provided, such as Gas recirculation fans and spray attemperators --both as aids in controlling final steam temperatures over the load range. Boiler heat transfer surface typically is set to achieve the MCR load with the design FEGT, no attemperation in the reheater and a minimum load on the gas recirculation fan.

Q. What Happens Next?

A. Proposals were submitted to Black and Veatch containing the performance guarantees, such as MCR achievement on the specified fuel blend, schedules and the costs required to provide a system that would successfully achieve the specified performance on the PFP. The proposals would be reviewed, approved and provided to PEF who would evaluate and one vendor would be selected by PEF. A contract would be constructed typically by taking the RFP (1), the vendor response proposal (2), and any specific correspondence clarifying (3), and identifying specific items that might have been cloudy-these documents together are the CONTRACT. The contract must contain the guarantees, and those in this case included Emissions (NOx), performance at specified loads, a maximum continuous load, when firing a specified fuel (The Design Fuel). The guarantee document with specific guarantees for CR4 and CR5 is shown in Exhibit ______ (JAB 9).

Q. Was this process followed in the cases of CR4 and CR5?

A. Yes. PEF's predecessor issued a request for proposals. Black and Veatch, which incidentally has earned a reputation as a premier company in the design of coal-fired units, submitted a proposal that became the basis of the contract under which the project went forward.

Q. What did PEF's predecessor, Florida Power Corporation, specify as the "design basis" fuel?

A. FPC chose as the "design basis" fuel for CR4 and CR5 a 50/50 mixture of Powder River Basin ("PRB") subbituminous and bituminous coals containing 10,285 Btus per pound and reflecting a specific profile of ash, moisture, and other characteristics.

Q. What are the implications of the choice of the 50/50 blend as the "design basis" fuel?

A. The fuel selected impacts every part of the design of the plant except for the turbine generator and feedwater systems. Once the planners at the PEF had decided to specify a blended fuel of 10,285 BTUs/pound and a specific output this would then set the tons of fuel required per hour to provide the output.

The initial impact is the amount of coal to be handled. If BTUs per pound are reduced, then the total pounds will be increased to meet the same specified output. All the fuel equipment from conveyer belts, relaimers, crushers, silos, feeders, and pulverizers would have to be larger and consume more power.

The specified fuel has a unique ash characteristic. That ash characteristic will impact the furnace design due to their propensity to slag or foul. If the ash is indexed as a Severe Slagging vs High Slagging, the physical plant will have to be larger to permit control and removal of the slag deposits. The same reasoning applies to the fouling index applied; if higher, it would impact the arrangement of convection pass surface and sootblowers, affecting the "box" size as well as platforms and building sizes and air heater surface arrangements.

The specified fuel's ash will determine allowable gas side velocities thus also impact the size of the "box". The elements in the ash will also effect pulverizer wear life and thus impact maintenance costs of the plant.

The specific fuel will have a specific ash content and that will set the size of the ash removal system, and the size of the electrostatic precipitators.

The specific fuel impacts the combustion air requirements thus fan sizing.

The specific fuel contains a specific moisture which will affect gas weights and thus plant efficiency, air heater sizing and pulverizer capacity.

Q. Please discuss the capacity ratings of CR4 and CR5 that bear on the issue of output using different fuels.

There are two capacity ratings of the boilers and related equipment that are relevant to the issues raised by PEF's witnesses. Unfortunately, the distinctions are blurred by them to the point that their testimony is unclear and misleading.

Q. What is the first capacity rating?

A. There is the full load rating corresponds to the turbine nameplate rating with standard conditions. The total plant heat balance will be made using these conditions. In most cases this also the MCR rating. There is always some margin above the full load rating within the boiler and turbine designs in most cases just to insure that FULL LOAD performance can be made and guarantees met. This is a standard rating where the boiler operates at the its operating pressure and temperatures specified and the turbine operates with its control valve open only enough to produce the full load nameplate rating.

Q. Please describe the second capacity rating to which you referred.

A. On occasion some utility clients will request a "peak" or Maximum Continuous Rating which vendors respond to with the special "100% wide open control valves" at the turbine and 5% over pressure from the Boiler vendor. Typically that is a short term rating used by the utility to match its peak generation period of several hours per day. The most common manner in which this condition is met is to increase the steam pressure to the turbine. The standard is to raise the operating pressure of the boiler to 5% over the full load operating pressure. The increased pressure in turn increases the steam flow to the turbine and thus the heat input to the steam generator must be increased to keep the heat balance in balance. This level-turbine valves wide open, 105% of operating pressure and a new higher steam flow-all together are referred to as MCR. MCR is not fuel specific: it is heat input specific. To make MCR one must input the required quantity of

BTUs. This then is the TRUE maximum or full load condition even if referred to as MCR because the steam generator must be designed to meet this peak "heat input" condition. In the case of CR4 & CR5 the MCR specified was not several hours per day to meet peaks; it was specified as continuous, and thus becomes the design full load guarantee point for the vendor.

Q. Given the "cap" or limitation of 5% overpressure are the units as capable of maintaining 5% overpressure on a sustained basis when burning the 50/50 blend as they are with 100% Bituminous Coal?

A. The design basis for these CR4 and CR5 was the specified 50/50 Blend and the steam generator is capable of sustained MCR and in fact has been guaranteed to maintain on a sustained bases MCR with that specified fuel.

Q. Could a unit exceed MCR output with either bituminous coal or the 50/50 blend?

A. As a practical matter, the answer is no. There are several bottlenecks in a complex assembly such as a power plant that could acting separately be the load limiter or CAP once above the MCR point. The most common and immediate of these limiters is typically the safety valve set points on the steam generator's drums. If a load higher than MCR is attempted, more steam flow would be required. As steam flow is increased in a pipe, the pressure drop increases exponentially and thus the drum pressure required to "push" more steam through the superheaters would most likely exceed the popping set points on the drum safety valves. The choice of fuel burned has no effect on this type of mechanical limitation.

RESPONSES TO SPECIFIC ASSERTIONS BY PEF WITNESSES

Q. Mr. Hatt (see page 7, line 13) and Mr. Toms (see page6, line 19) state that CR4 and CR5 are rated for generating 665 megawatts of energy per unit. Do the PEF witnesses accurately portray the capacity ratings of CR4 and CR5?

A. No, they do not.

Q. Please explain.

A. There is a name plate turbine rating of 665 MW, which is a nominal full load rating that corresponds to a certain steam flow of 4,737,900 pounds of steam per hour at a steam outlet pressure of 2500 psig. This is the nominal full load rating of Units 4 & 5 at Crystal River. The second and governing rating, as it is more demanding, is the MCR rating, which includes elements of turbine valves wide open, boiler overpressure of 5%, and a higher steam flow of 5,239,500 pounds of steam per hour, of all of which required greater heat inputs to sustain. These are major differences.

Q. Mr. Hatt claims, at pages 6 Line 17, that PEF would have lost 124 megawatts of output (combined) from CR4 and CR5 if it had burned the 50/50 blend of PRB and bituminous coals during the period 1996-2005. Mr. Toms makes a similar claim at page 8 line 22, How do you respond?

A. The witnesses speculate that, while CR4 and CR5 generated at MCP (that is, at 5% overpressure, turbine valves wide open and higher steam flow), the units could not have performed above the normal rating of 665 MW when burning the 50/50 blend. To answer them, I must divide my response into two parts, because Mr. Hatt purports to attribute this claim to shortcomings in the design of the boilers and also to limitations on the ability of the coal handling system to supply the necessary quantities of the 50/50 blend to sustain the output of CR4 and CR5 at the level that PEF experienced with bituminous coal. Each "leg" of Mr. Hatt's claim is demonstrably false.

Q. **Let's begin with Mr. Hatt's discussion of the boiler. At page 38 lines 8, 9, Mr. Hatt asserts that CR4 andCR5 could not have been designed to accommodate PRB coal, because at the time they were designed the combustion properties of PRB coal were not known. Is he right?**

A. No. Mr. Hatt is mistaken. The boiler vendor, Babcock & Wilcox, through experiments in its coal research laboratory, provides the industry's technical basis for using a solid fuels ash analysis to predict boiler slagging and fouling potentials from indexes derived from those data. Indexes have been developed using both experimental data obtained in the laboratory and in the field on real units burning real fuels from hundreds of steam generators and thousands of fuel/ash samples collected over the past 85 years. These indexes, created over many years, have proven to be quite accurate and in fact provide the confidence for offering guaranteed performance. It is believed these indexes are the bases upon which most commercial offerings, world wide, are available today. These indexes have been created for many fuels including Sub Bituminous, Bituminous, and Lignites, have all been published, are in the public domain, and are used widely. Babcock & Wilcox's Book, "Steam Its Generation and Use," is the generally accepted technical "bible" on this subject.

The operational issues on Slagging, Fouling, i.e. the ash issues have been well understood since the early 1970s for the Sub-Bituminous fuels, the early 1960s for lignitic fuels, and from the 1930s for Bituminous coal. The design and materials provided for construction of CR4 and CR5 acknowledged these issues and designed accordingly. Due to the desire to have maximum conservatism, the units were designed for Severe/Severe-- the most conservative design index that could have been applied.

Q. The timing of this knowledge of Sub Bituminous fuels and ash has been raised and how it might relate to being applied to CR 4 and CR5.

A. Exhibit __ (JAB 7) "Experience with High Sodium Subbituminous Coals," and Exhibit __ (JAB 8) "Experience with High Sodium Lignites," provide examples of test burns of subbituminous blends in units designed only for Bituminous Coal as early as 1973. Those units were designed in 1951. There were test burns of blends prior to 1973 in units designed for only Bituminous Coals that are not covered in the exhibit. There are also units designed for 100% PRB prior to 1970 not included in the exhibit. Exhibit 8 provides 1960 history with high sodium lignitic ash, from which boiler designers have learned much to prepare them for design of Sub-bituminous units.

Q. When were CR4 and CR5 Designed?

A. CR4 and CR5 were designed in 1978/79 and thus benefited from all prior experience, test burns and laboratory advances on the subject of blends.

Q. What is a high-slagging coal?

A. In steam generator design the furnace is the zone where ash deposits that are laid down via various mechanisms such as slag impact and that will retard heat transfer. If heat transfer is retarded, the flue gases get hotter and the slagging rate increases-raising the FEGT (Furnace Exit gas Temperature) which will impact fouling and *if uncontrolled* will result in a forced derate (to shed slag) or shut down to remove fouling deposits. All fuels except natural gas will lay down slag deposits that can retard heat transfer. The slag must be removed. Deposits cannot be removed if molten-- thus the gas temperature the slag deposit "sees" is the deposit temperature. The designer must make the furnace as large as possible to permit cooling of the flue gases. The easy way to evaluate the degree of conservatism is to review the Furnace Exit Gas Temperature (FEGT) at MCR. The lower it is, the better-- and the only way to get it lower is to increase the size of the furnace for the same heat input...a most expensive cost impact and a step not taken lightly. The designer, however, by controlling flue gas temperatures (how tall is the furnace), the number, location, and elevations of furnace wall sootblowers (devices to remove slag), input per burner (amount of heat per square foot where lower is better, burner spacing (where wider is better), depth of furnace (where deeper is better) and load reductions (reduces furnace temperatures and thus slag temperatures) are all tools designers can apply at the time of design to permit slag removal. The load reduction tool would be seen by the client as a peak load limit-2 hours per day or 4 or whatever but there would have been a limit which would have been invoked by the supplier if the slagging index was rated as severe because that ash from the specified fuel was not predictable and there was uncertainty. In that situation a peak load requested/demanded by the client would be met with "Limits" of time, never would it be continuous.

Q. Please discuss "fouling."

A. Fouling is once again related to the ash properties in the coals being fired. At the high furnace temperatures where slagging is a problem the ash components that create fouling problems are vaporous and in the gas phase will not be a problem until they condense. When it condenses (Sodium, Potassium etc) typically upon convection pass heat transfer surfaces (tube metal temperatures at 1100F or below being well below the gas temperatures) such as superheaters and reheaters it forms a glue like base to capture other solid particles in the gas/ash stream. These condensed salts can sinter over time as they remain at a high temperature and become hard to remove. They also have great tensile strength and can bridge across to parallel surfaces. As they bridge and are not removed, the gas temperatures will increase pushing fouling back further into the horizontal convection pass. In extremes they can close off the free flow path of the flue gases restricting load or forcing a shut down. Fouling can be controlled in several way first and foremost by controlling slagging and the resulting increased FEGT. The designers can provide flexibility by increasing the side spacing of parallel surface such as Platens or pendants that contain superheater or reheater steam internally. For example, these side spacings could be as close at 12 inches or as wide as 60 inches. The depth of the pendant (direction of gas flow) could be 12 feet or as short as 6 feet. The design of "wraparounds" (devices to keep pendant surfaces in alignment) could be intrusive (into the gas clear side spacing) or non-intrusive. The leading edge material of the pendants could be any material as required by the ASME Pressure Part codes or upgraded to an austenitic SS which has demonstrated reduced bonding strength between the fouling deposit and the tube. The number of sootblowers (long retractables) could have an effective cleaning radius of 24 feet or 4 feet. All the slagging /fouling design tools described above are made more conservative with a higher index.

Q. What is the index?

A. There are two-one for predicting the difficulty of removing slag, and one for predicting the difficulty of removing fouling deposits for each major fuel type-Bituminous, Sub-Bituminous and Lignite. The Index see Exhibit________ (JAB 5), "Boiler Design

Considerations," is a relative scale that predicts the difficulty the boiler designer will have in removing a deposit from the boiler heat transfer surface during normal operation. It requires an analysis of the components of the ash resulting from combustion of the specific coal. It is not the ash analysis of the material in the coal-- it is the ash that is formed when the coal is combusted. Most vendors now have laboratory ashing furnaces that permit sample quantities of coal to be combusted under controlled conditions and the ash created to be collected and analyzed. The components of that ash can be reduced to ratios of various components, and the test ash ratios can be compared to actual experience obtained both in the field and laboratory from thousands of coal ash samples and experiments conducted over time. The ratio can be used to make predictions with a great deal of confidence on which certain ashes are rated as higher slagging potentials or higher fouling potentials. A "high" slagging coal is one that is more difficult to remove than a low slagging coal and less difficult to remove than a "severe" slagging or a severe fouling coal-the index that the industry recognizes as the worst possible ash. There are many severe slagging bituminous coals, there are many severe slagging lignite coals, and there are many severe slagging sub-bituminous coals.

Q. **What index was applied to the design of CR4 and CR5?**

A. The ash produced from the specified blend for CR4 and CR5 was not rated as severe, either from fouling or slagging standpoints. It was rated high/medium. Thus if the blend had been the only coal Babcock & Wilcox had been directed to use for the design basis, the reduced FEGT, the large furnace, the increased side spacing, the extra complement of soot blowers and all the extra conservatism added for SEVERE/SEVERE would not have been provided. The reason CR4 and CR5 are so conservative from a slagging/fouling design point could have been the requirement for MCR at the blend. The supplier, Babcock & Wilcox, elected to add an additional degree of conservatism to the design index by raising both to the highest (Severe/Severe) when the ashes from all fuels considered (Design 50/50% PRB Blend and 100% Illinois) would have suggested a Medium Fouling index be applied.

Q. Does the designation of a coal or blend of coals as high slagging and high fouling mean that boilers cannot operate successfully with it?

A. No. It means the boiler must be designed to accommodate such properties.

Q. Were the boilers of CR4 and CR5 designed to accommodate these properties? If so, how?

A. Emphatically, yes. The boiler island is composed of several major sub-systems. I will answer by providing a response to the effect on each of the major subsystems

Furnace Sizing

The specified 50/50 blend carried a Bit coal (CAPP) analysis such that if the unit was designed and guaranteed for that fuel only it would have resulted in a furnace and all associated auxiliaries sized for a design index related to a medium fouling, high slagging ash rather than what the blend required. The blend, for all the reasons provided in Mr. Hatts testimony, and those in the S&L report, demanded that the designers apply the utmost in conservatism in the design. The designers applied the most stringent criteria to the design by using a design index of Severe Fouling/Severe Slagging…the highest level in the Babcock and Wilcox design book. For the same MCR (guarantee point) fuel input, the more stringent index requires many physical increases that directly relate to such things as building size, both height and footprint; increased structural steel, both to support the greater load but also to overcome the greater wind loading with a taller structure. Why the increase in building size? Several reasons, but prime is that the furnace would have to be made larger in depth, in width and in height. For example the "furnace exit gas temperature" (FEGT) is a critical design element and for severe slagging fuel it must be at the lowest possible point. The same heat input is required no matter what slagging or fouling index is applied to make the MCR, thus the only way to decrease this critical slagging related design control tool is to make the furnace larger. A larger Furnace will increase the amount of particle residence time and the amount of water cooled surface the products of combustion (including ash) have (and "see") to cool down before they impact convection pass heat transfer tube surfaces and furnace sidewalls. Once cool (below its softening temperature (T250) the ash can be removed by sootblowers. However the ash, if not cooled, can still be hot enough to exist in the molten/semi liquid state where the slag cannot be removed and additional deposits will continue until the point, load (guaranteed MCR) would have to be decreased to "shed slag". Decreasing load, is in essence, reducing the FEGD, making the furnace cooler and is an effective way to control slag. It would have required a load shed to achieve, which was not permitted by the continuous MCR specification. In this case the designers had to design into the steam generator a lower FEGT. This lower or more conservative FEGT was then available at the guaranteed MCR with the blended fuel and could meet the heat balance requirements required to meet the thermal performance guarantees.

A severe slagging rating would also require more furnace sootblowers and more elevations of furnace sootblowers along with the associated piping, platforms and stairways to provide maintenance access to them.

Convection Pass Sizing

Severe Fouling as an applied index impacts the arrangement of the convection pass heat transfer surface and thus impacts (increases) height, width and depth of the convection pass in the steam generator and thus the building. The amount of clear side spacing between furnace pendants and convection pass platens (heat transfer surface for superheaters and reheaters) typically hung from the roof are critical to being able to control the fouling of ash particles in this zone. Also bank depths (direction of gas flow) are decreased because the effective cleaning radius of retractable sootblowers is reduced with severe fouling fuel. If uncontrolled the fouling will result in the unit not attaining final steam temperatures (effecting MW output, Turbine efficiency, guaranteed performance) and eventually reducing gas flow to the point where a forced shut down is required for ash shedding. The severe fouling index fuel (i.e. the guaranteed 50/50 blend connected to MCR) required the designers to be guided by conservatism and maximize the clear side spacing, minimizing the back spacing (had been found to reduce ability for fouling desposits), and redesign the method of alignments utilized. These design tools took advantage of the lessons learned from Babcock & Wilcox extensive fuel blend/fuel burn/fuel-ash analyses history.

The horizontal convection pass (primary superheater, primary reheater, economizer) all would have increased clear sidespacing and thus require more volume for the same heat transfer. Here again, more sootblowers would be installed with the associated requirements for piping, platforms and access.

There are gas side velocity limits and these would have been reduced which would impact due to the greater gas weights and change in ash composition (ash with higher silica/alumna ratios are known to be more erosive). Thus, the allowable velocities had to be reduced for the 50/50PRB blend (ash weight, gas flow) and erosion concerns which in turn would have an impact on the width and height of the horizontal convection pass.

Q. What about Mr. Hatt's prediction, at page 37, of the effect of "eutectics"? Did the designers of CR4 and CR5 provide for this phenomenon? If so, how?

A. Yes, they were anticipated and dealt with. Once both ashes were well known, the combination or formation of harmful higher fouling potential eutectics was reviewed. Our review indicated that, while eutectics would be expected to form, they would not further degrade the potential for slagging or fouling already established by the base coals in this case. The point here is that these units were designed for the blend and the ashes resulting from those blends. This design would not have been possible without the extensive PRB blending tests the vendor had carried out for years before these CR4 and CR5 units were designed.

Q. At page 37, lines 9-10, Mr. Hatt says utility experience has shown that, to minimize slag, it is better to burn either 100% PRB coal or a small percentage blend. In your opinion, given the design of CR4 and CR5, is it necessary to burn either 100% PRB

or a small percentage blend in these units to avoid eutectics, or any other of Mr. Hatt's predictions?

A. It is not necessary to do so in the case of CR 4 and CR 5. The design objective has to be to burn the fuel that is specified and to understand that fuel and its ash effects in sufficient depth so as to provide the trained operator with the tools to minimize slag/fouling effects upon maximum load carrying capability. Once you are at that point, then, and only then, can you guarantee an MCR with a blend fuel. Mr. Hatt, I believe, refers to trial burns where the steam generator was designed for only one fuel, in this case a CAPP type fuel only, and made trial blends with other coals. Those trials in some cases limited loads because the boilers being tested were never designed for the alternative fuel. In JAB exhibit 8 extensive detail is provided on blends and their effect on boilers not designed to handle them. Whether it was a 50/50 blend or 100% PRB used at CR4 and CR5, by all the knowledge we possess today those units would meet their MCR guarantee.

Q. Is there a place for the 30%/70% rule of thumb?

A. The situation is analogous to an oil fired unit claimed to be coal capable for limited periods of time and at some reduced maximum load, (such as I think either Bartow or Higgins were designed to be), or oil designed and fired units that would burn a combo of Venz Oil and Indonesian Oil where one oil might dominate and at what load. Utilities have many examples of units firing blends they were not designed to handle, such as PEF firing Pet Coke blended with Capp Coal, or Synfuel with CAPP OR VENZ, CAP COAL, SYFUEL. On units designed to fire dual fuels such as oil and gas it is important to be able to predict when one will dominate since heat absorption is drastically effected. It is generally accepted as true that one fuel will become dominate but no one can predict with any reasonable degree of certainty at what blend point that might occur-other than a guess at somewhere between 30 and 70% in those units *not designed for the blend.* Thus, a boiler vendor will/has invoked the 30-70 rule of thumb to provide guidance to users.

CR 4 and CR 5 were designed for, guaranteed for MCR with a 5050% PRB blend. These were not "trial" designs and could therefore and did evaluate the fuels' slagging/fouling potential in total as a blend and design for it.

Q. At page 35, Mr. Hatt says that even if CR4 and CR5 may have been "nominally" designed for a 50/50 blend, the older sootblowers in those units "may not be suitable to effectively deal with PRB slagging." Were these units only "nominally" designed for the 50/50 blend?

A. Mr. Hatt is badly mistaken. These units were extensively and expensively designed for the blend see Exhibits ____ (JAB 5 and 7). The Slagging/Fouling indexes applied in the design stage are the most conservative that could have been applied. However, in any mechanical system a prudent designer would leave space for additional Operational tools to be added to control slagging and/or fouling if experience proved it necessary. In this case the tools are sootblowers to be added if experience proved it necessary. The provisions for these "futures" can be seen by any casual observation of Crystal River Units 4 & 5. A ten inch capped pipe nipple protrudes from the lagging in the upper furnace and horizontal convection pass area. Provisions were also made in the design phase for the additional piping, valves and controls necessary for these "adds" if and when they are ever required. This indicates that the pressure parts have been designed and hardware provided for the addition of more soot blowers should actual experience with the design fuel or even an off design fuel prove they are needed. It should be noted these provisions come with a cost and the benefit is to the client as he can add them without suffering a forced shutdown...because these were foreseen in the design.

Q. Please comment on Mr. Hatt's statement that the older sootblowers of CR4 and CR5 may not be suitable to deal with PRB coal effectively.

A. Mr. Hatt is wrong again. The sootblowers provided are manufactured by the Diamond Power International Company and are the IK 500 series for retractables and the furnace blowers are of the IR design. They are still in utility service all over the world for fuels indexed as severe slagging/severe fouling. The blowers were at the time state of the art for PRB fuels on units designed for PRB fuels and had proved their adequacy for Bituminous fuels for over 30 years. The vendor of course guaranteed adequacy for the blended fuel and provided additional locations for futures as and if required. The total numbers of blowers and their locations were set once a Severe/Severe ash index had been applied to the design. One factor that was learned in the early 70s was that the sootblower control system, not the blowers per se, had to provide more flexibility for simultaneous operation of several blowers. The application of these devices to these units did not occur until almost 10 years after the initial PRB test burns on units designed for bituminous coals had been completed and design information integrated within vendor design manuals. Increased flexibility in control systems was immediate.

Q. At page 38, Mr. Hatt discusses the fouling properties of PRB coal. He asserts that at the time CR4 and CR5 were designed no one understood the chemistry of fouling, and consequently the "simple sootblowers" currently installed are inadequate to deal with fouling. He also predicts that PEF would need to space superheater and

reheater tube banks farther apart to contend with fouling. He estimates the cost of boiler modifications necessary to deal with fouling to range from $5 million to $ 10million, and calls this estimate "particularly conservative." Is he right?

A No. He is wrong. There would be no capital required to modify the convection pass, because the modifications he suggests are already designed into the units. Exhibit ____ (JAB 7), the operational issues on Slagging, Fouling, i.e. the ash issues have been well understood since the early 1970s for the Sub-Bituminous fuels and from the 40's for Bituminous. The design and materials provided for construction acknowledged these issues and designed accordingly. The blend did present an operational issue challenge relating to slagging/fouling-which is the more demanding fuel since no one could have or can predict even now the "worst" and thus the answer was to design for the most demanding and that was to apply the Severe/Severe Index.

Let's review the Fouling approach:

For example the side spacing on the furnace platens (the first convection pass surface) for CR4 and CR5 is 60 inches compared to St. Claire (a 1973 test burn on a bituminous design unit) at 10 inches. This difference recognizes the difference in fouling potential between a fuel designed for bituminous and one designed for a blend. These differences carry on through out the convection pass.

The second design tool concerned with fouling control is bank depths. It is recognized that a sootblower's effective cleaning radius is reduced with Severe fouling fuels. The platens scale at approximately 4 feet depth (using the 6 foot standard man located at the bottom of the side sectional elevation view of CR4 or 5 (CWT2 page 4 of 13) compared to St Claire approximately 12 feet. This difference recognizes the difference in the effective clearing radius for the severe fuel ash index applied to CR4 & 5

Q. At page 39, Mr. Hatt predicts that burning the 50/50 blend in CR4 andCR5 would lead to fouling and dust accumulation in the economizer and pluggages of the air heater, which in turn would cause deratings. He concludes, "Even as designed with all the sootblowers operating, the air heaters in Units 4 &5 would still have these problems when burning the PRB coal. This would cause more unit down time for boiler repair." What are your comments?

Once again Mr. Hatt is referencing a result expected from a test burn on a unit not designed for the blend. He has not analyzed these specific designs.

A. Economizer-This surface is part of the convection pass heat transfer surface and the vendor had addressed this area by noting three impacts were expected in this zone from the blend. They were as follows: 1 pluggage, 2, erosion and 3, ash removal. Each of those were addressed by the designers: (1) increased clear side spacing between elements and decreased back depth, recognizing the reduced effectiveness of the sootblowers, (2) Gas side velocities were reduced to 65 ft/sec to reduced erosion potential, and (3) hopper size under the economizer was increased to aid in creating a reduced gas velocity zone, which would assist in ash drop out and increased storage capacity (larger hopper) to capture that dropped out ash.

AIR HEATERS

Regenerative air heaters were provided both for primary and secondary service.

The Secondary air heaters (SAH) were designed for the blend (per W Toms exhibit 2 Exhibit PEF FUEL 004091) and thus had the surface and the spacing to process the specified fuel.

The Primary (PAH) which provides air to the pulverizers would have had to be sized for the requirements imposed by the 50/50PRB blend at MCR guarantee as well. The PRB fuel is a lower BTU/# fuel, thus requiring more of it (more tons per hour) than if designed for 100% BIT. The increased moisture also impacts design, because the primary air heater would have to have more heat transfer surface in it to (1) evaporate the higher moisture in the coal and (2) heat more air. As an example of the magnitude of the differences, the outlet hot air temperature needed for the guaranteed MCR 50PRB case is 541F and the units were so designed-if designed only for the Bit coal the required air temperature would have been 441F (23 % more temperature required for the PRB SUB BIT). In addition, the total heat required would be higher as the airflow is higher. In addition fouling concerns would tend to favor more open heat transfer spacing to insure clearance. The seventh mill add (future) would have required more primary air, thus the provision for the seventh mill future had an impact on the primary air heater as well. It should be noted that this is a system, and thus all components, the flues, ducts, control dampers were impacted (became larger), which affected all the steel layouts and sizing to provide access-these are massive conveying ducts. The primary air fans would have had to be increased in volume and static capability to handle the higher tonnage resulting from the PRB 50% blend, and also for the potential 7th mill addition.

Q. At pages 39-50, Mr. Hatt predicts that the burning of the 50/50 blend would cause a decrease in boiler efficiency and a corresponding increase in fuel costs. Does he make a valid point?

A. If the 50/50 blend were burned, the boiler would be at its guaranteed efficiency of 87.6% (10,285). The heat balance method utilized to calculate the steam generator efficiency could provide a slightly higher efficiency for the straight non specified CAPP Coal (12,822) (Acceptance Test) was 88.8%, or 1.1% differential and that difference would translate directly to an added fuel requirement and added costs. Recall the Blend PRB was a low BTU 8200. Off setting any efficiency difference calculated on the original blend would be the present 1996 PRB 8800 BTU fuel. Thus, the differential in efficiency between what was purchased and what could be achieved with a non design fuel (CAPP) would be less than ½ of 1%. While these numbers are important, one should realize that in this efficiency number is a 1.5% manufacturers margin, which overshadows any of the efficiencies we are thinking about.

Q. At page 46, Mr. Hatt says that PEF would have to invest in new blending facilities, additional pulverizers, and dust suppression facilities before even undertaking a test burn of the 50/50 blend. How do you respond?

A. I have shown the new blending facilities and additional pulverizer are unnecessary. Putting that proof aside for a moment, I cannot comprehend why anyone would want to invest that amount in a 20 day test burn and not apply, as all others have who have undertaken test burns, a better way that involves the operational staff of the unit. In general test burns will tell all one needs to know in three weeks or less. The only question is, Are the units going to slag or foul uncontrollably? Additional attention to house keeping would be required, and extra maintenance personnel would be required during the test burn to insure accepted housekeeping levels are maintained for the PRB and blend fuel. Let me try to provide specific answers in three parts.

1- The Black & Veatch design manual for these units, sets out in the greatest of detail the design fuel, a 50/50% PR Blend, and basis of the fuel handling system-it would be designed for 50 % PRB coal delivered by barge with 3 deliveries per week. The CAPP coal would be delivered by rail. All new conveyor systems would be designed for dust suppression at transfer points, fire deluge systems and dust collection. Wash down systems were not provided universally but at strategic locations. Burn rate with the design blend fuels were 330 tons per hour at MCR. The blending was to be accomplished with two stacker reclaimers and two separate coal piles, one CAPP and the other PRB. The live pile would be created by the stacker reclaimers taking weighed quantities from both piles and blending them to reach whatever % was desired, but capable of the 50/50 design point.

2-Pulverizers were sized to produce MCR with the PRB blend fuel using only 5 mills. The 6^{th} is a spare for the blend fuel.

3- Dust suppression was provided for in the initial design, the initial construction and initial operation. Our inspection indicates those systems have not been used and in most cases have been removed. Dust collection is a good practice for any solid fuel, even bituminous, and Crystal River Operations would be prudent to reactivate the dust collectors provided for any solid fuel.

Q. How does Mr. Hatt incorporate these and other design elements into his "seam to stack" analysis?

A. Mr. Hatt ignores them. In fact, his entire testimony seems to be geared toward a scenario in which a conversion of equipment that was not designed for PRB coal is taking place. This is not surprising, given his erroneous assumption that CR4 and CR5 were designed before the PRB combustion properties were understood, but this failure—and one more gap in his approach—skew his discussion and lead him to wrong, unsupported conclusions.

Q. What is the other omission in Mr. Hatt's approach?

A. Incredibly, nowhere does Mr. Hatt mention the design specifications of the boilers or other equipment that Black and Veatch specified, that Babcock & Wilcox designed and constructed, and that Babcock & Wilcox guaranteed. The information is readily available in contract documents and unit design manuals maintained by PEF. To ignore such information is to say, "Don't bother me with the facts."

Q. What do the contract documents and the design manuals reveal?

A. They reveal that from an early point the objective of PEF's predecessor, and the commitment of the design firm and Babcock & Wilcox, was to have units capable of maintaining 5% overpressure on a sustained basis when burning the 50/50 PRB/bituminous blend of coals. In fact, Babcock & Wilcox guaranteed that the units would be capable of maintaining 5% overpressure without limitation.

Q. Is such a guarantee typical in the industry?

A. No. The guarantee went farther than is typical of the industry. The Industry typically looks to cover peak periods (4 or 6 hours per day) with peak generation and thus a typical guarantee at MCR is for 4 or 6 hours. PEF demanded and received a sustained 24h/day guaranteed MCR with the specified fuels.

Q. What are the implications of this guarantee?

A. The guarantee obligated Babcock & Wilcox to stand ready to remedy any shortcoming of design or installation that prevented the units from operating at 5% overpressure on a sustained basis. Had Babcock & Wilcox provided units incapable of such operation, Babcock & Wilcox would have been liable for expensive re-engineering and physical modifications to honor their contract. In fact, Babcock & Wilcox experienced such a situation when Florida Power Corporation settled with Babcock & Wilcox to enforce Babcock & Wilcox's contractual guarantees with respect to Babcock & Wilcox's participation in the design and construction of Crystal River 3. Because Babcock & Wilcox had committed to a high level of output of CR4 and CR5 on a sustained basis, and was aware of the implications of that commitment, Babcock & Wilcox came up with what were probably the most conservatively designed boilers that came across my desk during my tenure with Babcock & Wilcox.

Q. Do you have any exhibits that illustrate this was the case?

A. Yes. Throughout the process of contracting for the plant, PEF was consistent in the vision or concept of buying a plant firing blended western and eastern coals, blended at the plant site with a base loaded turbine that would operate consistently at 5% overpressure with valves wide open at some MCR initially estimated by Black and

Veatch at 700,000 kW and later when the plant was better defined at 770,000 kW. To support this statement I have several exhibits.

I have attached as Exhibit _______ (JAB-2) Florida Power's RFP to Black and Veatch dated March 10th where in Appendix A Pages A-2 and A3 I excerpt certain quotes to demonstrate the design concept of the owners at inception: "Boiler will be capable of burning a wide range of coals," "Unit is to be designed to operate at 5 % overpressure continuously without time limit considerations", "Unit shall be designed for cyclic operation", "coal blending and beneficiation facilities are (to be sic) included", and in the main letter page 7 (J V Maloney to Black and Veatch) "coal selection for design purposes will be supplied to A/E on or about 1 May 1977. For quoting purposes the coal will be predominantly Eastern Coal with some blending of Western Coal. Coal will be sized and washed at the mine and blending will be handled at the power plant. Recrushing will be performed at the power plant prior to pulverizing"

- Exhibit _____ (JAB 3) (Black and Veatch letter to J Maloney dated April 15, 1977 transmitting Black and Veatch Proposal Section 11 Project Description Section 3 Mechanical Equipment where I extract "turbine generator shall be designed to operate satisfactorily at 105 per cent normal throttle pressure (2520 psig 1000F 1000F) with valves wide open and ….. The expected turbine capacity at this condition will be approximately 700,000 kW. The steam generator and all auxiliary equipment will be designed for continuous operation at this condition" 3.2 Steam Generator maximum capacity will include sufficient pulverizers to supply the unit at maximum capacity (4,750,000 at 2620 psig 1005F) when firing a range of low sulfur coals. The unit will be capable of operating at maximum capability with worn pulverizers and one pulverizer out of service" "The furnace will be designed for continuous operation at maximum capability without excessive slagging"

Black and Veatch Engineering Contract with PEF dated 24th June 1977, where the Black and Veatch proposal is made part of the contract along with the FPC RFP.

Babcock & Wilcox Proposal Response to Black and Veatch Request for Proposals Exhibits _____ (JAB 9) I quote from the Babcock & Wilcox Unit Description as follows:

> "The maximum continuous rating is 5,236,900 lb/hour of main steam flow at 2640 psig and 1005F….." "Fuel The guarantees for this unit are based on firing a 50/50 blend of eastern bituminous and western sub bituminous coal" "The furnace and convection pass are designed for a severe slagging and severe fouling coal" "Higher heating value for performance (guarantee) is 10,285 Btu/pound"

Summarizing included documents: Proposal summary Sheet P12-4657-16y0-1s0 provides the detailed guaranteed performance at various loads with the specified 50/50 coal blend. CIS Sheets 101.4 and 101.3 show pulverizer capacity as designed and as provided for the specified fuel blend and the alternative Illinois deep mine.

- All the above are irrefutable facts of the concept and actual design provided to PEF to achieve their vision-continuous operation at the 105% pressure turbine valve wide open on a blend of 50/50 PRB/CAPP coals.

Q. How did the contract contemplate that the parties would implement the contractual guarantee?

A. A guarantee that would be good for a year after declaration of commercial operation. PEF had the opportunity to test performance and either accept the components or demand the components be made right. The second unit provided a two year gap if the performance of the first unit was in any doubt.

Q. Did PEF's predecessor claim that the unit did not meet contractual requirements?

A. No. Florida Power Corporation accepted the units.

Q. Did Florida Power Corporation burn the 50/50 blend during performance testing?

A. No. Florida Power burned only bituminous coal during initial performance testing. I am attaching as Exhibit ___ (JAB 10) an excerpt from the results of the original performance testing. Having exacted an expensive guarantee from the vendor, having paid considerably more than a bituminous-only power plant for a unit designed to burn the 50/50 blend, and having accepted the units and released the vendors from contractual obligations based on tests performed with bituminous coal, PEF now proposes to bootstrap its own questionable decision not to fully test the units by speculating on what the units could or could not do when burning the 50/50 blend they were designed to burn.

Q. You mentioned that PEF paid more for CR4 and CR5 than it would have paid for units that are designed to burn only bituminous coal. Please elaborate.

A. There are several areas within the fuel transfer, blending and boiler island that were impacted by FPC's decision to specify performance and require guarantees of MCR at a 50/50 PRBV blend. I will take them in order of financial impact on the PEF.

Boiler Island

Steam Generator Sizing as a function of: FUEL ASH PROPERTIES

Furnace Sizing

The specified 50/50 blend indexed at Severe/Severe carried a Bit coal (CAPP) analysis such that if the unit was designed and guaranteed for that fuel only it would have resulted in a furnace and all associated auxiliaries sized for a design index related to a medium fouling, high slagging ash. The blend, for all the reasons provided in Mr. Hatt's testimony, and those in the S&L report, demanded that the designers apply the utmost in conservatism in the design. The designers applied the most stringent criteria to the design by using a design index of Severe fouling/Severe slagging...the highest level in the Babcock and Wilcox design book. For the same MCR (guarantee point) fuel input the more stringent index requires many physical increases that directly relate to such things as building size, both height and footprint; increased structural steel, both to support the greater load but also to overcome the greater wind loading with a taller structure.

Q. Why the increase in building size?

A. Several reasons, but prime is that the furnace would have to be made larger in depth, in width and in height. For example the "furnace exit gas temperature" (FEGT) is a critical design element and for severe slagging fuel it must be at the lowest possible point. The same heat input is required no matter what slagging or fouling index is applied to make the MCR, thus, the only way to decrease this critical slagging related design control tool is to make the furnace larger. A larger Furnace will increase the amount of particle residence time and the amount of water cooled surface the products of combustion (including ash) have (and "see") to cool down before they impact convection pass heat transfer tube surfaces and furnace sidewalls. Once cool (below is softening temperature (T250) the ash can be removed by sootblowers. However the ash, if not cooled, can still be hot enough to exist in the molten/semi liquid state where the slag cannot be removed and additional deposits will continue until the point, load (guaranteed MCR) would have to be decreased to "shed slag".

Q. Is there any other way to decrease FEGT?

A. Decreasing load, is in essence, is reducing the FEGD, making the furnace cooler and is an effective way to control slag, but since it would have required a load shed to achieve, the designers had to design into the steam generator a lower FEGT. In fact the CR4 and CR5 units are not always at MCR and thus load reduction is an operational tool the operators could apply when and if required. This lower or more conservative FEGT was then available at the guaranteed MCR with the blended fuel and could meet the heat balance requirements required to meet the thermal performance guarantees.

Q. Does a unit rated for severe slagging require more sootblowers?

A. A severe slagging fuel would require more furnace sootblowers and more elevations of furnace sootblowers along with the associated piping, platforms and stairways to provide maintenance access to them.

Q. What happens to Convection Pass Sizing?

A. Severe Fouling as an applied index impacts the arrangement of the convection pass heat transfer surface and thus impacts (increases) height, width and depth of the convection pass in the steam generator and thus the building. The amount of clear side spacing between furnace pendants and convection pass platens (heat transfer surface for superheaters and reheaters) typically hung from the roof are critical to being able to control the fouling of ash particles in this zone. Also bank depths (direction of gas flow) are decreased because the effective cleaning radius of retractable sootblowers is reduced with severe fouling fuel. If uncontrolled the fouling will result in the unit not attaining final steam temperatures (effecting MW output, Turbine efficiency, guaranteed performance) and eventually reducing gas flow to the point where a forced shut down is required for ash shedding.

Q. What did the Severe Fouling index used impact at CR 4 and CR 5?

A. The severe fouling index fuel (i.e. the guaranteed 50/50 blend connected to MCR) required the designers to be guided by conservatism and maximize the clear side spacing, minimizing the back spacing (had been found to reduce ability for fouling desposits), and redesign the method of alignments utilized. These design tools took advantage of the lessons learned from their (Babcock & Wilcox) extensive fuel blend/fuel burn/fuel-ash analyses history.

The cost impact here includes building volume. If the clear sidespacing is increased, the width of the unit will be impacted, while the change in "backspacing" reduces the heat transfer effectiveness and thus requires more surface to compensate for that loss – thus more volume and weight impacting structural steel requirements.

Decreasing the depth of each pendant (recognizing effectiveness of cleaning radius reduced with severe fouling fuels) creates more cavities where sootblowers could be placed to control the fouling. Thus more cavities, the more horizontal length required to pack in surface, the more sootblowers, more piping and platforms and stairways and building volume.

The horizontal convection pass (primary superheater, primary reheater, economizer) all would have increased clear sidespacing and thus require more volume for the same heat transfer. Here again, more sootblowers would be installed with the associated requirements for piping, platforms and access.

There are gas side velocity limits, and these would have been reduced, which would impact due to the greater gas weights and change in ash composition (ash with higher silica/alumna ratios are known to be more erosive). Thus the allowable velocities had to be reduced for the 50/50PRB blend (ash weight, gas flow) and erosion concerns which in turn would have an impact on the width and height of the horizontal convection pass.

Q. What would be the impact to the Combustion System?

A. As designed, five pulverizers could have carried MCR with the CAPP fuel only and had some spare capability. This would have meant only five rows of burners, five rows of burner pipes, five levels of ducts for windbox air supply and five sets of controls. As provided, five pulverizers could just meet the guaranteed MCR when burning the specified 50PRB blend (8,125 BTU/#) with no spare capacity; but, with 1990s PRB fuel at 8800 Btu/,# there is spare capacity in the 5 mill PRB50% condition. The pipes themselves had to be increased in diameter to handle the higher tons/hour fuel load and higher moisture PRB Blend. It was considered prudent by the supplier to provide 6 pulverizers that would meet the guarantee MCR 50% PRB Blend and have spare capacity-in fact, one spare mill at the guaranteed MCR load point. This reserve is normal utility practice, and going to 6 mills is not an incremental cost for the base Bit case Vs the guaranteed MCR50%PRB blend, but the larger pipes and the clearance space required for them are.

Adding the 7^{th} mill would be called for only if PEF desires to have the capability for an additional spare in the event the utility want to increase PRB coal beyond the 50% in the blend, or if the BTU value per pound dropped from the design basis. In fact, however, the PRB BTU values per pound have increased, thus providing more spare milling capacity with only the 6 mills provided. The 7^{th} mill addition would have provided pulverizer capability to go to 100% PRB and/or provide future additional spare capacity. However, it was a condition of contract with the 50% PRB Blend that space, etc, be made available for a 7^{th} mill and its associated system requirements.

Engineering the space into the building, and actually providing the space and associated clearances for the fuel handling equipment such as: coal tripper, silo, feeder, pulverizer, hot and cold air supply ducts, coal pipes to burners, burners, windbox, secondary air supply, control and measuring, pressure part openings in the furnace, structural load allowances for all the added loads to be added to the existing steel, controls, motor control centers, breakers, burner igniters, burner scanners, burner and coal pipe platforms result in a major impact on the design, space allowances and anticipated structural loads that would have to be designed in the support steel even though the loads were future the steel had to be sized, rooms had to be sized, auxiliary power systems sized, primary air heater, primary air fans all had to be purchased and sized, the buss bars as well control systems expanded and capability all purchased at the original start.

Q. Would the fuel specified have impacted the cost of the air heaters?

A. Regenerative air heaters were provided. The Secondary air heaters would have had to be sized for the air requirements of the blend at MCR and the expected fouling potential of the blend. The Primary (PAH) would have had to be sized for the additional requirements imposed by the 50/50PRB blend at MCR guarantee. The PRB fuel is a lower BTU/# fuel, thus requiring more of it (more tons per hour) than if designed for 100% BIT. The increased moisture also impacts design because the primary air heater would have to have more heat transfer surface in it to evaporate the moisture and heat more air.

Q. How large is the heat load difference between the design basis blend and the CAPP?

A. This is an example of the magnitude of the differences. The outlet hot air temperature needed for the guaranteed MCR 50PRB case is 541F, and the units were so designed. If designed only for the bituminous coal, the required air temperature would have been 441F (23 % more temperature required for the PRB SUB BIT). In addition, the total heat required would be higher, as the airflow is higher. Fouling concerns would tend to favor more open heat transfer spacing to insure clearance. The seventh mill add would have required more primary air, thus the provision for the 7^{th} mill future had an impact on the primary air heater as well.

It should be noted that this is a system and thus all components, the flues, ducts, control dampers were impacted (became larger) which affected all the steel layouts and sizing to provide access-these are massive conveying ducts. The primary air fans would have had to be increased in volume and static capability to handle the higher tonnage resulting from the PRB 50% blend, and also for the potential 7^{th} mill addition.

Q. What cost impact would the design have on the electrostatic precipitator?

A. The precipitator design was specified for ash and gas flows resulting from the 50 PRB fuel blend MCR guarantee requirement. For his reason, it physically is larger than one required for CAPP Bit only fuel. Hatt's testimony pointed out that the resistivity of the ash is lower and thus the "space velocity" (a design criterion used by vendors and AEs to insure conservatism) must be reduced to insure particulate capture. In addition, more frequent cleaning would be required; thus each ESP (2 per unit) was oversized to permit one to be removed for cleaning without forcing a shutdown. The specifications were so tight that it is obvious the design fuel was the PRB 50/50 Blend. The Spec included such requirements as: space velocities 3 fpm under all normal operation, number of fields (5), Aspect ratios 2.0, 55 degree minimum hopper angle, required hopper heaters (relates to concerns with the high PRB calcium ash plugging the removal system), isolation dampers and the design coal table 2-2 indicating that any coal with the properties within the range outlined on Table 2 were performance guarantee fuels and coverage by their broadness the PRB Blend MCR design case. The number of hoppers, the size of ash removal equipment, and storage capability would all be impacted as the guarantee 50%PRB Blend required a higher tonnage of coal. The ESP provided for CR4 and CR5is a most conservative design, suitable for the guaranteed conditions. The oversizing to meet guaranteed performance (Blend at MCR) impacts the housing sizing, number of ash hoppers, hopper heaters, ash removal system, power supplies, rigid plate design, rapper system employed, the size of flues to and from, the dampers at exit and entrance, support steel and the foot print required for the units.

Q. How did the blend impact the fuel transfer system?

A. Black and Veatch clearly were directed by PEF to design for two separate fuels that had to be keep segregated and were to be blended to achieve an as "fired" heat content of 10,285 BTU/# Exhibit _____ (JAB 10) Black and Veatch Document Summary Important Information 7645.41.0601.22. 7/15/80. Per this document it was projected (designed) that half the fuel (CAPP) would arrive by 70 unit car trains and half (PRB) by barge resulting in a requirement of about 3 barge unloadings per week at the barge unloading design rate of 1500 tph. Our site visit indicated that the barge unloading facility appeared to be only working at half the design rate-their estimate was 700 tph at the time of design (7/15/80).

Q. Were the barge unloading facility upgrades in the scope of Black and Veatch for the CR 4 and CR 5 project?

A. The Barge unloading facility and associated transfer conveyors would have been necessary in any case for two reasons (1) to fuel Units 1 and (2) PEF elected to receive CAPP coal via barge as well as train. However, Black and Veatch had no scope in the unloading facility and did not take design responsibility until transfer point 24, providing coal to Units 4 and 5 only. Dust suppression, Fire protection, Deluge system and wash down capability were required for either fuel and were provided in the Black and Veatch scope area. The incremental cost impact on these systems would have related to the capacity issue (tonnage) and served to require an increase the system to provide the required 50% CAPP/50% PRB BLEND and obtain the equivalent BTUs. This corresponds to an approximate 28% increase in tonnage from the PRB coal to match the 50% of total BTU input required. Can be quantified by the added requirements for larger belts, larger transfer stations, larger motors, more support steel and foundations

Q. Did the concept of on site blending have an impact on cost?

A. The Black and Veatch concept and the design that was followed was to use two stacker/reclaimers with two separate piles to blend to a third pile, and then reclaim from that third. The impact here included the additional real estate, the second stacker reclaimer, the associated belts (32 or 33) (35a or 35B), tracks, transfer points, motor controls, auxiliary power sizing to the redundant reclaimer, and the second reclaim belt to the crusher house feed belt/transfer station. Black and Veatch warns in their design that if "operators" were required for the two stackers it would add the equivalent of $2,960,000 in capital costs to the $16,022,000 they estimated the cost of the system to be at the time of design. Blending would require operators. 100% crushers were provided with 100% redundancy, and with the higher tonnage the crushers were both 56% larger (with no margin) than required for CAPP coal only-- along with their motors, motor control centers, auxiliary power supplies, housing, foundations, dust and fire suppression systems and foot prints.

Q. What do you mean by "with no margin"?

A. It would be normal practice for Black and Veatch to add some capacity factor to the base burn rate required for the crushers, but I do not know what it might have been. I might be overstating the % larger than required vs actual (CAPP) for the crusher at 56%.

Q. Could you provide an approximate cost estimate of these additions to have the ability to burn PRB 50/50 Blend specified?

A. On the sub systems described above, obtaining detailed cost estimates is not possible in the time permitted. However, we have provided an estimate of the incremental cost additions/deductions the PRB blend would have had added as a percentage of the total "as purchased" costs.

Q. Would you provide these estimates?

A. Yes. Boiler Island: The impacts identified above, if *not* included in the CR 4 and CR 5 designs, would have resulted in decreased cost to FPC. Our estimate of the incremental cost increase due to the required and guaranteed PRB 50% MCR blend is 18% on the D & E total costs and most probably higher as a percentage of the original design (Black and Veatch engineering costs), equipment (where excess design costs had to be included with the material), and construction costs of the boiler island. Per Precipitation: The cost estimate impact to make this suitable for the design fuel would be a 35% increase in the total cost (material and construction), as the volume had to be larger to achieve the lower space velocities, the 5 fields rather than 3, affecting the footprint and the hopper angle at 55 degrees affecting the height, more steel, foundations, ash removal systems and isolation dampers.

Fuel Transfer System: The conveyor system had to have dust suppression, fire protection, and deluge potential in any case, but tonnages were higher by 28%. The two/stacker reclaimers were provided for blending, and thus represent almost 60% of an additional incremental cost required for blending. No blending would have meant no secondary conveyers (32 or 34) and (35A or 35B), with no central reclaim pile required, the footprint decreases by 66%, along with auxiliary power, motor control centers, operators control room-- as well as the operators for only one stacker/reclaimer.

The overall cost increase associated with having to provide for blending would amount to 40% of the original fuel transfer system.

Q. At page _7_, lines 18 & 19, Mr. Toms asserts that the larger "box" necessitated by the plan to burn a mixture of PRB and bituminous coals enabled PEF to generate at 5% overpressure with bituminous coal. How do you respond?

A. The units were designed to operate at overpressure on a continuous basis with a specified fuel-they would operate at that point with many non-specified fuels, such as some of the blends PEF tried during the past 17 years. Mr. Toms, like Mr. Hatt, fails to mention that the maximum capability rating of CR4 and CR5 when burning the 50/50 "design basis" blend of coals is the same maximum output that PEF achieved with bituminous coal. Either Mr. Toms is unaware of the design standard and corporate guarantee applicable to CR4 and CR5 when burning the design fuel, and is also ignorant of the limitation of 5% overpressure that caps the generation of the boilers regardless of fuels being burned, or he chose to ignore these factors.

SEVENTH PULVERIZER

Q. At page 32, Mr. Hatt states, "Finally, I noticed on my site inspection of Crystal River that although CR4 and 5 were designed to include an additional silo, feeder, and pulverizer unit at each plant, these additional structures <u>were never built.</u> So the design features needed to burn a 50/50 blend of PRB and bituminous coal that Mr. Sansom speaks of in his testimony are missing very critical pieces of equipment. Building and operating these additional structures would be inherently necessary to

burn a 50/50 blend under Mr. Sansom's theory which depends on the design basis of the units." Is he correct?

A. No, he is incorrect. With 6 miles, there is, no shortage of the equipment needed to operate at the MCR guaranteed rating, and that includes a full complement of pulverizers with one spare unit....and that was spare when the specified blend was at a 10,285 BTU/# level. The higher BTU levels currently available would increase the "amount" of spare capacity at the guaranteed MCR. Exhibit _____ (JAB 9).

Taken from Babcock & Wilcox Unit Description (PEF-FUEL-)004090 BOILER I am quoting "The unit has 54 Dual registers burners, arranged in three rows of nine burners each on both the front and rear walls." From Scope of Supply: "Six MPS pulverizers size 89G and piping to burners", from FUEL "guarantees for this unit are based on firing a 50/50 blend of eastern bituminous and western sub-bituminous coal", "Performance fuel higher heating value is 10,285 BTU/#", CIS Sheet 101.01 Pulverizer Design Curves labeled "50/50 Blend Coal" all confirm that the boiler was designed and built to maintain MCR with 5 mills and the sixth is a spare on the performance design specified coal.

Exhibit _____ (JAB 11) consist of Black and Veatch Coal Handling Documents 7645.41.0601.22, 7645.42.0605.12, 7645, and 7645.42.0602.12, all of which pertain to the coal handling system at CR4 &5. Mentioned through out these official specifications for this plant are references to the specified blend, 50/50 PRB, the specified Btu/# values of 10,825 and all tonnage rates at 330 t/hr, which is the MCR burn rate with the blend with margin. In addition, 6 silos are the number for 6 pulverizers, with six weight scales and six vibrating feeders. Black and Veatch as well as PEF believed 6 mills was the correct number for the specified PRB 50/50 Blend at MCR.

Exhibit _____ (JAB 12) is FPC's specification to Conveyer Bidders Dust Abatement "Eliminating of Dust resulting from coal transfers is of paramount importance," indicating all involved were knowledgeable of the importance of eliminating dust with the PRB coals.

Exhibit _____ (JAB 13) is FPC's specification to conveyer Bidders-FPC 61-4220 040779 provides the specified fuel analysis range, which includes eight different 50/50 PRB blends. The #4 column matches the final selection for the specified design fuel.

Exhibit _____ (JAB 14) (OPC Locator CR4 Coal Conveyor Equipment 2-2-4) Section 21 Coal silo unloading conveyors are specified under 21-2 Design Conditions Material Temperatures 800F "Smoldering Coal".

There is simply nothing in the available documentation that would support the position that the 7th mill is needed for the 50/50 blend MCR specified load point. In fact, it becomes evident, as one reviews the design documents, that the designers were well informed concerning PRB fuel and the need for careful dust control. Also in plain view is the plan to blend on site.

Q. At page 34, Mr. Hatt opines that, because the pulverizers must work at a lower capacity to grind the 50% bituminous coal to a finer grade, "this will necessarily

slow the fueling process at Units 4 and 5, which will lead to power production derates." Is his concern valid?

A. No, it is invalid. Again, Mr. Hatt starts with a recitation of properties of PRB coal and leaps to an unwarranted conclusion—one which he would have known to be unwarranted had he bothered to consult the design parameters and design capacities of the pulverizers.

I do not understand why he would think the fueling process would slow down-I assume he means load up to produce the required heat to the boiler for the heat balance. More tons are required if each ton has less heat in it to make the required guaranteed heat balance. If his point is that capacity falls off in a mill as you change to the design blend, it does, of course, and less tons of coal can be milled; so, some of the design reserve capacity is utilized, as the mills must process more pounds of the specified coal to make the heat required. This decrease in capacity was known and taken into account by the designers of the pulverizers.

The pulverizers had to be increased in size for two reasons – the drying required with the higher moisture fuel adds to the recirculation load within the pulverizer and the increased tonnage. The increased tonnage is offset somewhat by the lower HGI (an index used to predict power required to achieve a certain fineness in the product output). The maximum mill capacity for these MPS 89 G pulverizers 140,100 pounds of CAPP coal per hour (70t/hr). The maximum mill capacity of the Blend in the same mill is 127,000 pounds per hour or 63,500 Ts/hr. This relates to a 10% reduction in mill capacity, which was not sufficient to force an additional pulverizer to be added. The unit was designed for 6 mills, 6 miles are ample to achieve MCR, and 6 mills were provided.

- Please see Exhibit _____ (JAB 9) Cis 101.03 Mr Hatt also raises the issue of coal pipe sizing. He asserts the present pipes would be undersized for the 50/50 design blend. This not the case, as they have been sized for MCR and the specified design 50/50 blend.
- A similar alert issued by Mr. Hart concerns the adequacy of the regenerative air heaters and raises two issues- (1) how the requirement for higher primary air temperatures with 50% PRB and (2) the potential for fouling/pluggage of the surface would increase with PRB coal. Here again, the designers were aware of the issue and would met the guaranteed performance of 5050%PRB blend at MCR with equipment designed for the intended purpose.
- Mr. Hatt asserts the lack of an inerting system on the pulverizers, and his capital estimate includes one, but, in fact, one was provided within the initial pulverizer scope. It required external hook up, and that was deferred by PEF.

Therefore, Mr. Hatt'ss prediction of deratings based on inadequate pulverizer capacities is completely bogus. However, Mr. Hatt could have mentioned, but chose not to mention, that a diet of 100% bituminous coal will result in faster wearing of pulverizer components than would the processing of the 50/50 PRB/bituminous blend that the units were designed to burn.

Q. Please explain.

A. Pulverizer wear elements are an expensive maintenance item. The average PRB wheel life (3 per pulverizer) on sub-bituminous coal is projected to be in excess of 35,000 (PS of Colorado Comanche #2) hours, while wheel life on eastern bituminous coals are in the much shorter 18-20,000 hour range (AEP GAVIN). The abrasive elements in bituminous coal ash are the silica, alumna and iron. An index has been proposed for Silica alumna ratio that could be tied to wear life, but it is still being developed. It is interesting to note that one can get almost twice the wear life with PRB coals than with eastern Bituminous.

COAL HANDLING AND CONVEYING SYSTEM

Q. At page 27, lines 14 through 24, Mr. Hatt worries that the coal conveyors from the coal storage area to the units would not be capable of supplying the increased quantities of blended coal that would be necessary to sustain full output and also leave time for maintenance. How do you respond?

A. Please see Exhibit _____ (JAB 11). The systems were designed for the 10,825 Btu/# specified blend and can manage to deliver those tons that correspond to the demand heat input. Let's look at the actual situation and determine if there is a problem.

- How many tons of the specified fuel are required per hour?

  The initial impact is the amount of coal to be handled. The input required to meet the output specified is 6,398,000 MBTUs per hour at MCR. This equates to a required fueling rate of 523,000 pounds per hour of CAPP Coal at 12450 BTUs per pound. If 50% of the input required is to be contributed by PRB fuel at 8125 BTU/# then 393,335 pounds of PRB would be required per hour.

- This contribution plus 50% of the CAPP coal of 257,000 pounds per hour would be the required fuel rate of 650,700 pounds of coal per hour. In fact, if the blended BTU/# value given is at 10,285 that BTU value would require 622,000 pounds of coal per hour to meet the specified output. Let's use the 50/50 calculated number, as it is higher. This is 26 % higher than a 100% CAPP specification would have required. All coal unloading, conveying, storage, reclaim, crushing, surge and storage silo system sizing would have had to be increased by at least 26% and most likely something larger would have been utilized to provide a safe margin. This corresponds to a 325 ton/hour fueling rate to maintain MCR at the guarantee level. The reclaim system is designed with two 800 tph conveyors to feed two 800 tph crushers to feed two 800 tph conveyors to the surge bin with 4 x 400 tph outlets to two boilers. To keep two units at MCR with the specified fuel requires 325 tph x 2 or a 650tph feed rate. Available capacity using only *one* of two systems available is 800 tph, or 23% greater capacity than is needed to maintain MCR. 123% redundancy provides for lots of maintenance time. In fact, the plant operates both of the systems in parallel, and thus in 24 hours the unit will require 325 x 24 or 7800 tons of specified blend fuel. With one system dedicated to one unit this could be accomplished in 9.75 hours, leaving 14 hours for maintenance. The silos, however, are only sized for 8 hours of fuel, so the fueling has to done over two shifts and the limit would seem to be-not the transport system-but the size of silos.

IMPLICATIONS OF TEST BURNS ON FULL LOAD CAPABILITIES

Q. At page 47 lines 1`2-14, Mr. Hatt refers to the 2004 effort to conduct a test burn, and notes that capacity suffered during the aborted test. He also alludes to a 2006 test

burn, then states the two exercises were "inconclusive." How do you respond to his characterizations?

A. There were two test burns and in my opinion they were conclusive. I believe they were also conclusive to Strategic Engineering (Raligh PEC), who recommended proceeding, in several areas. See Exhibit ______ (JAB 15) and Exhibit ________ (JAB 16).

The PRB Blend, not the specified blend but at something between 18% - 22% PRB, had been transported and off loaded using the existing conveyor systems, transfer houses, crushers, surge bin and coal silos-all without any mention of additional housekeeping or hosedowns, and experienced no explosions. Observations during the handling indicated little dusting.

In addition, on the 2004 test it was learned that several "hammers" were not functioning in the Electrostatic Precipitator on Unit 4 and dust emissions were a problem. In the 2006 Test on #5, the blend dust emissions were reduced as compared to CAPP and non spec (Venz/Syn) blend coal only situation.

Both tests confirmed in the emission area what everyone knew-NOX emissions were reduced, SO2 emissions were reduced and opacity, if the precipitator was maintained, would remain same or be reduced.

The 04 test indicated that LOI was high on Unit #4, but a sample taken from Unit #5 at the same time confirmed it was not from the PRB fuel but most likely from the Venz/syn coal in the blends. Typically the industry would expect a lower LOI from PRB fuels if the mills/burners are set for the fuel.

The tests confirmed that if you have soot blowers that are operational, they clean the surface; and, conversely, if soot blowers are not functioning, you would permit slag deposit to form.

In 2004 the feeder controls functioned as designed, and limited load to the mills to a preset value-the CAPP heat/tonnage value. They had not been reset to match the lower heat value of the test blend, thus acting to limit load.

The plant staff proved capable of managing the blends and the only inconclusive portion to me was that plant management opted to blend offsite and not use the on site facilities and learn how good they are.

BLENDING TWO COALS AT THE CRYSTAL RIVER SITE

Q. Are you aware of any indication that the original plan of PEF's predecessor, Florida Power Corporation, was to blend the PRB and bituminous coals at Crystal River?

A. Yes. The contract documents and design manuals maintained by PEF are replete with evidence that Florida Power Corporation directed Black and Veatch to provide the means to blend the PRB and bituminous coals on site.

Q. Please identify the documents that establish that the plan of Florida Power Corporation was to blend the two coals at Crystal River.

A. The vision and concept of blending at site a PRB and CAPP coal was in place from the very beginning, as well as at the final design. I use these excerpts to support that statement:

- The RFP from PEF dated March 10, 1977 to Black and Veatch clearly calls out in the Main body of the letter and the attachment A "Scope of Work" that blending is to be done at Crystal River. I extract quotes from the letter: Coal selection for design purposes will supplied to the A/E on about May 1, 1977. For quoting purposes, the coal will be predominately Eastern Coal with some blending of Weston Coal. Coal will be sized and washed at the mine and blending will be handled at the power plant" From Attachment A: "Boilers will be capable of burning a wide range of coals. The fuel to be burned will be determined later"

  Exhibit_______ (JAB 2)

- Black and Veatch Proposal response to the PEF RFQ states in the cover letter that the "proposal responds directly to your Request for Proposal and is intended to include the complete Scope of Services you have specified as required for the project" Exhibit_______ (JAB 3)
- Black and Veatch Contract (Agreement for Engineering Services dated 24 June 1977) incorporates the PEF RFP letter and Attachment A as a portion of the project description. Exhibit_______ (JAB 4)

- Black and Veatch System Design Specification 7645.42.0602.12 on page 1-6 states that "Blending for Unit #4 and #5 will be accomplished as follows: During coal unloading, coal directed to TTP 26, Coal A, will be split to both conveyor No's 32 and 33. Coal on conveyor no 32 will be stocked out in the active storage piles of stacker reclaimer No 3. Coal on conveyor 33 will be blended with Coal B reclaimed by stacker reclaimer No2 and directed into the units....when a barge or train is unavailable, blending will be accomplished in the same manner, but with Coal A being supplied by Stacker Reclaimer No 3. Exhibit________ (JAB 17)
- Black and Veatch System Design Specification 7645.41.0601.22 Page 6 Section 3.0 Analysis Coal Handling System states under 3.2 Requirements paragraph 3 "The stock out and reclaim systems will provide for the handling, storage, and blending of at least two types of coal. Complete segregation of the two coals is required prior to blending" Exhibit________ (JAB 18)
- The fuel specification issued to all conveyor vendors by PEF Exhibit________ (JAB 13) indicates all fuels to be designed for with 8 specific blends indicated. The final specified design blend is included

Q. What did Black and Veatch do in response to Florida Power Corporation's directive?

A. Black and Veatch planned and designed a sophisticated system for blending on site that provides flexibility and redundancy. The detailed design excerpt provided above Exhibit _____ (JAB 18) details exactly what the "blend on site" concept was and how to execute the blending for all barge/ train variables, as well as the no train and/or no barge, and how they designed for each variable. The Black and Veatch Design Specifications also include details for weighing each stream accurately (Black and Veatch 7645.42.0605.12); on the need for 100% redundancy (Black and Veatch 7645.42.06.04.12); on the need for accurate sampling (Black and Veatch 7645.42.0601.12); Control (Black and Veatch 7645.42.1207.12); dust control, and fire protection through out the detail specifications.

Q. At page 25, line 18, through page 26, line 19, Mr. Hatt questions the ability of the existing two stacker reclaimers to blend PRB and bituminous coals adequately. How do you respond?

A. The two stacker reclaimers are the centerpieces of the system. When Mr. Hatt asserts that they are not accurate enough, he overlooks two important points: (1) the weigh scales that are part of the blending system, which he fails to mention and which provide the means to ensure ongoing accuracy of blending; and (2) the operating systems of CR4 and CR5 that would sense any discrepancies in the ratio of coals and adjust the splitter gates if directly fueling from either barge or train or automatically, with no loss of output.

Q. Please describe the location and function of the weigh scales that Mr. Hatt overlooked, and their significance to the blending operation.

A. Blending with coal received on Conveyor 31 is accomplished by belt scales No 31 and 32, indicating to the control system that a specified amount of coal is being split off to stacker reclaimer #3. Simultaneously, Belt scale Nos 31, 32, and 34 will provide data to the control system for controlling the reclaim rate of stacker reclaimer No 2 . In the event no coal is being delivered by Conveyor #31, then blending takes place using only the two stacker reclaimers. Data from belt scale No 32 and 34 to the control system will enable the reclaim rates to be set on both machines. If stockpiled blended coal (pile 3) or non blended coal from either pile 1 or 2 is required from a single stacker reclaimer, then the belt scale on the respective yard belts will enable control of the reclaim rates.

Q. Earlier you mentioned the capability of systems within CR4 and CR5 to detect any variations in blend ratios and make adjustments without any diminution of output. Please explain.

A. In the large view the steam generator is a heat machine. It senses immediately when the heat input is reduced while at a constant output. The controls call for more coal. This would be an indicator that the Btu/# value has dropped off. If it calls for less coal, this is an indication to the operators that the Btu/# value has increased. As PEF discovered during test burn #4 with the 22% PRB Surge, the coal feeder speeds are adequate to feed sufficient coal to maintain load if the alarm limits placed on them during initial set ups are readjusted for actual fuel heat levels. In my opinion, the controls are capable of handling a + or – 20% variation in fuel Btu/# heat content over some reasonable period of time. This is about what they were required to do in 2004as the 22% PRB test blend was introduced to the silos-it did not arrive at the burners all at one time and thus the controls adjust automatically as the heat demand is reduced or increased. As one would expect, with a scale out of calibration, the change would not be instantaneous.

Q. Mr. Hatt contends that PEF would need to spend some $37.8 million on a different type of machinery to blend the two coals. Is he right?

A. No, he is mistaken. Because of the manner in which weigh scales have been incorporated into the blending scheme, and because of the ability of the unit control systems to adjust for any discrepancies even in the unlikely event they occur, to scrap the stacker reclaimers and replace them with a different type of equipment would be to waste customers' money. The *only* valid point that Mr. Hatt made concerning the stacker reclaimers is that PEF should add washdown capability. However, this is easily and inexpensively done. Rather than the $38.7 million that Mr. Hatt says PEF should spend on new and different blending apparatus, the appropriate value is approximately $50,000 for the two units.

Q. At page 27, Mr. Hatt asserts that because there is only one conveyor from the barge unloading point to the north storage area, a barge and train cannot be offloaded at the same time. At page 28, Mr. Hatt adds, "The coal yard and the conveyor belt system are not currently able to accommodate blending of PRB coal," and alludes to indications that provisions were made for an additional conveyor belt from Transfer point 24 to a point north of transfer point 25. Does the space allotted on the ground for an additional conveyor belt prove that the existing conveyor belt is inadequate for on-site blending?

A. No. Mr. Hatt should have consulted the original design before concluding that a second conveyor was designed but not built. I have reviewed the original design documents. The original plan provides only for the one conveyor belt from the barge unloading point to the north storage area, the one that was built, and it is fully adequate to serve the on-site blending function. Returning to fundamentals, let's start with the actual fuel required to maintain MCR with the specified blend and then determine what additional capacity was designed in by Black and Veatch to handle stocking and reserves and maintenance downtimes. Input for MCR with the specified fuel is 6,398,000,000 BTUs per hour/per unit.

Exhibit________ (JAB 9). The specified coal has a heat content of 10,285 BTUs/#. 622,000 pounds per hour/unit therefore are required to maintain MCR. This reduces to 311 tons/hour of the specified coal x 2 (for two units) or 622 tons per hour. Black and Veatch System Analysis Coal Handling 7645.41.0601.22 used a design burn rate of 660 tons/hour for the design bases of all the conveyor, crusher, surge bins, transfer point, silo feeds etc with variations only to provide either a higher capacity or 100% redundancy.

Exhibit________ (JAB 18). A new transfer point 23 was created to serve train only, and conveyor 11 was modified. Train coal could then go to several points, including Transfer Point 24 for fueling Units #4&5. Thus, the coal yard people could unload a train and have that fuel isolated from the barge fuel. Barge unloading for PRB would eventually arrive at transfer point 24 via conveyor 29.

TP 24 feeds conveyor 30, and 30 feeds TP25 and then 31, which is the only north bound conveyor that can fuel CR4 and CR5. Since it was desirable to segregate the two fuels, they could not be co-mixed on Conveyor 30. Both 30 and 31 are designed to carry 2,500 tph of the specified fuel. Requirement is 622 tph; actual provided is 2,500 tph. Daily fuel rate required is 14,928 tons, daily capacity is 60,000 tpd. Thus, it would appear that 24% or 6.0 hours of the available capacity of one day is required to provide fuel for MCR for both units. Designers were aware of the difference in angle for repose for PRB vs CAPP, but provided variable speed drives where prudent to provide flexibility in delivery rates. On those drives that are fixed, it is a simple and low cost modification to change the gear set and increase the capacity that way, but it appears unlikely to ever be necessary with the spare capacity built in.

- The stacker/reclaimers have similar redundancy (100%), Page 8-2 of JAB Exhibit 20 shows a 2,500 tph stack out rate and a 1600 tph reclaim rate for the specified blend. The requirement for MCR atboth units is 622 tph vs 1600 provided, or, stated differently, the system is 153% oversized. There are two stacker reclaimers; thus, if required, there is over 300% spare capacity. Downtime for maintenance 38,400 tpd available (not counting second stacker) vs 14,900 tpd for MCR or 0.38 of a day or 9.33 hours, leaving more than 15 hours available for stacking or maintenance.
- The crushers and associated conveyors are sized for 800tph with 100% redundancy. The requirement to fuel MCR with blend fuel is 622 tph, vs the 800 tph provided. This is 28% more capacity than required, plus another 100% available. Down time for maintenance at 19,200 tpd vs the 14,900 or 29% spare capacity. 0.77 of the day or 18.6 hours. 100% spare provides all the time required for maintenance. Path is then from surge bid to silos and each unit has two 400 tph feeders to fuel the silos. Again 100% redundancy plus the 311/400 or another 28% oversized conveyor. Please note I am calculating Actual – Required/Required to determine the spare percentages.

I can find no specified blend coal feed constraint in any of the systems provided. In fact they all have a healthy margin for additional capacity.

ADEQUACY OF COAL STORAGE CAPABILITIES

Q. At page 25, Mr. Hatt worries that to blend PRB coal, PEF would have to increase the quantity of coal in storage from 500,000 to 600,000 tons. Is his concern warranted?

A. Again, Mr. Hatt should have consulted the original design parameters of the CR4 and CR5 projects. I did. Black and Veatch provided for 850,000 tons of reserve storage, along with 43,000 tons of active storage. I don't believe his concern is warranted. PEF apparently agrees, as they have elected to reduce stockpiles to the 40-50 day requirement. See Exhibit ___ (JAB-18). PEF would need to compact the pile of reserve PRB coal as they are presently doing for the CAPP and would need only to supply rubber-tired equipment for the purpose of replacing steel tracked, or trading them to the south CAPP reserves. However, any incremental costs associated with maintaining the larger inventories in this fashion would be approximately $300,000 for equipment and the existing staff would not have to be increased.

TRIPPER FLOOR DUST COLLECTION

Q. At page 29, lines 20-24, Mr. Hatt criticizes the dust collection system of the tripper floor because its shape is not round. Does he have a point?

A. I agree that a round housing cover for the system is preferable to a square one. However, to change the shape from square to round involves only the fashioning of a small quantity of sheet metal and welding it in place. I also agree that I beam flanges should have slopes installed to minimized dust hide out during wash down. Both of these suggestions reflect best practices and should be installed. The cost of these modifications, undertaken as part of the required maintenance, would be insignificant.

PRECIPITATOR

Q. At pages 40-41, Mr. Hatt opines that PEF would have to add a sulfur conditioning system, at a cost of $2.4 million, to counteract the high resistively of PRB coal and enable the electrostatic precipitator to function effectively. How do you respond?

A. It is true that precipitators *not designed* for PRB fuels (those test burns again on Bituminous fired/designed units) did have problems with collection and sulfur had to be added to improved performance. At CR 4 and CR 5 the precipitators were designed for the PRB ash. All the criteria, such as number of fields, space velocity, collection area, angle of ash hoppers, heaters installed in the hoppers, would indicate to anyone familiar with the art that these precipitators were designed for a western PRB type fuel. Again, Mr. Hatt fails to recognize, much less consider, the excellent design that BV specified and implemented. The high resistivity of PRB ash was known at the time and provided for at the time. This resulted in precipitators that differ from those that would be built for bituminous-only operation. The number of fields, collection surface and space velocity permitted the vendor to guarantee that the precipitators would enable the units to operate at specified MCR; (the 5% overpressure, turbine valve wide open and a steam rate of 5,239,600 lbs steam per hour condition)and meet on a sustained basis the emission standards applicable to CR4 and CR5. Exhibit________ (JAB 19) Black and Veatch System Design Specification 7654.42.0701.12 Table 2-4 provides design specs and page 2-5 provides the tabulation of all the fuels it had to be designed to handle-...7 of the 8 total fuels provided were western fuels. It is only because PEF's predecessor chose to test perform the units with bituminous coal rather than the 50/50 blend the units were designed to burn that Mr. Hatt can speculate regarding the performance of the precipitators.

SILO MODIFICATION

Q. At pages 31-32, Mr. Hatt contends that PEF would need to spend $1-3 million to ensure that blended coal moves from silos to the pulverizers properly. Is he right?

A. No. Mr. Hatt describes the difference between "mass flow," in which the first coal to arrive in the silo is the first to leave, and "funnel flow," in which the first coal to arrive is the last to leave for the pulverizer. He says only that the arrangement at CR4 and CR5 *may* have characteristics of funnel flow. We did not agree but even if that is the case, there is a simple, readily available, and inexpensive measure with which to ensure the blended coal does not stay in the silo too long. Vibrators, rappers, pipe pokes and other state of the art devices could be attached to each silo. These measures would cost much less than the$1-3 million entry on Mr. Hatt's Exhibit __ (RH-8). Observing the Silo's during my plant visit it is obvious that the Black and Veatch design people knew about the PRB potential for flow problems. They utilized a stainless steel outlet right circular section of a cone, and they used an amazingly steep angle of discharge. Units not designed for PRB fuel did not use stainless outlets and minimized the discharge angle (some even used rectangles) to minimize the overall system height required. The steep angle pushes the eight hour capacity silo higher in the building since other distances, feeder to mill are fixed. Another feature of the design was that the downsprouts (from cone outlet to coal feeder) are fitted with removable half pipe sections to permit removal of coal from the silos during an outage. In addition, the deck just to the outboard of the coal feeders has been fitted with a bulkhead that can be removed so as to permit a truck to be below each silo on the ground floor and receive silo coal without the typical mess of dumping through a feeder. On Bituminous coal fired units that emergency discharge spout, if fitted, is below the feeder deck above the pulverizer. Placing it above the feeders on CR 4 and CR 5 is just another indication of a design for PRB coal. If the coal was on fire you would not want to ruin a feeder belt getting it out and thus would want to use a higher level dump. The coal feeders also are fitted with large inlets-17 inches, however larger would be better, but again leading one to the inescapable conclusion that this part of the coal feed system for sure had to be taking advantage of all that had been learned in the late 60s/early 70s about PRB coals.

ESTIMATES OF CAPITAL AND O&M NEEDS

Q. Please turn to Mr. Hatt's Exhibit __ (RH-8), which is his compilation of the additional capital and O&M costs that he contends would be necessary if PEF were to switch to the 50/50 blend. How do you respond to his contention that these expenditures would be necessary?

A. I suggest we go down his list and look at each item. I will make a brief comment on those that I have already touched upon in earlier testimony. If you note a BN this stands for something that would "be nice" but is not required initially.

- Wash down system – this is needed and was provided in most locations by Black and Veatch. The only area I did not see wash down capability was on the stacker/reclaimers. Since water is available in that area I would estimate that the addition would not cost more than $50,000 for both.

- Silo Modifications- I do not believe at this time anything is required. Test burns did not indicate a problem, design seems to have taken the lessons learned from PRB fuel to heart and applied them so this item, if required at all would consist of addition of poke holes and a upgrade of the existing CO sensors.

  Future if needed larger silo cone outlets $50,000

- Dust collections Systems-were provided in the original design and have not been maintained. It would not be a allowable capital item but must be a maintenance item. $0 Capital

- Fire Protection Systems-Again extensive Fire Protection was provided in the original design on all conveyors, transfer points, surge bins, silo feeders etc. They perhaps have to be maintained but no capital should be permitted as the capital has already been expended. $0 Capital

- Reclaim Hopper System-not required as present blend system has been designed, and engineered well enough to still represent the state of the art

  $0 Capital

- Additional Pulverizer-not required for specified coal at MCR

- Boiler Modifications-none required as original design suitable for MCR on specified fuel $0 Capital

- Water Cannons, Sootblowers BN $1.0 million

Not likely but water cannons could be required and this would be a delivered installed price for two units worth along with some furnace temperature acoustic monitoring to permit evaluations of usefulness.

- Upgrades to conveyor belts-None required $0 Capital
- Online computer analyzer-one of those nice things but is not (BN) Required with the Weighting system already provided $0 Capital
- D10 Bulldozer – trade off existing to south yard net capital $300,000
- Front loader-not required $0 Capital
- Upgrades to electrostatic precipitator-was designed for MCR $0 Capital
- O&M COSTS
- Dust suppression-ok as everything we know indicates this is $1 million a Good thing and should be the shelves for I beams, dust collector shields
- Power for two additional mills $0
- 1 additional person for fire watch $1K
- 2 Additional People for Wash downs $2K
- 2 Additional People to work piles-assume tripper $2K
- 20,000 gallons per day water for cannons $0 don't know if needed

sulfur needed for ESP flue gas conditioning $0
not needed

We have covered most of these capital additions and the need for them in our testimony earlier. My capital estimates amount to $1,400,000 for some things that are necessary (wash down), rubber tired bulldozer and one state of the art system such as fitting the furnaces with acoustic pyrometry. That system along with a water cannon or two would let you monitor your actual furnace temperatures and if required use the cannon; is not necessary but would be an excellent tool to have if ever needed. The O&M side needs more cleaners and dust suppression chemicals so I can support $1,500,000 in additional operational costs. Maintenance budget would take a major hit getting the dust collection and dust control systems back into shape. I think I would add an item not on Mr Hatt's estimate and that is the complete clean up of the existing tripper floors on both #4 and #5. The drains here have to be improved, the vacuum system if not operable should be made operable and the walls painted white with the enforced rule that the maintenance person responsible for the floor not go home until that floor is spotless. I would add $500,000 for the clean up, painting and drain improvements required

Q. Putting aside for a moment the issue of whether the expenditures are needed, please comment on the quality of Mr. Hatt's estimates.

A. They seem somewhat inflated perhaps due to the lack of time to get any industry estimates on the capital side. Much of the material (capital items) Mr Hatt recommends seems to be from a 1970's conversion wish list and does not reflect what is here. The O&M estimates look reasonable. I am puzzled as to why PEF did not use the Sargent and

Lundy high level Study they commissioned and paid for as the basis for estimated costs to convert to +50%- 100% PRB coal.

Q. Mr. Hatt criticies the S & L study because it simplicity states that CR4 and CR5 could burn the 50/50 blend without major expenses. How do you respond?

A. The Sargent and Lundy work product is a good assessment of the present state of the units. Their analysis supports the units' suitability for burning the design blend of 50/50% PRB specified. I agree on most everything on the technical side of the evaluation. These conclusions are well founded. The furnace is sized even more conservatively than present designs going out for PRB fuels, the horizontal convection pass is conservative and the downflow convection with a bare tube economizer is the current way to go for PRB designs. The fans are adequate for the MCR along with the electrostatic precipitator design. Their recommendations for 30% blend, would, if implemented, improve pulverizer performance, the rotating screen suggestion, but is not required to meet MCR with the specified fuel. Adding belt scales they suggest to 35A, 35B etc is redundant as they are already fitted with scales. S & L recognizes no additional pulverzers are necessary below a 70% blend. The other suggestions even though described as technical are in fact safety related and putting the mill inerting system back into operational shape is a good suggestion.

The other engineering evaluation that unlike Mr. Hatt, seemed realistic was that prepared by the Strategic Engineering Group (Raleigh) PEC who were charged with evaluating the PRB technical and economic benefits that might occur if applied at Mayo and CR.

Quoting from one of the Power Points used by PEC Raleigh group in answering the question "WHY CRN?" The presenter bullets indicated that:

"Units were designed for 50% PRB Coal" and

"had a large boiler box",

"large ESP","

"Sprinkler systems",

"dust collectors",

"mill inerting exists",

"Fuel handling can support with few mods".

The PP goes on to state competitive advantages,

- Gulf allows easy access from IMT,
- Can barge down the Ohio River and
- Supplier diversity

Sargent & Lundy Report see Exhibit________ (JAB 12) PAB at CRN2207.02.19

CONCLUSION

For all of the reasons I have stated, all systems of CR4 and CR5 were designed and constructed to perform at 5% overpressure when burning the 50/50 design basis blend selected by FPC.

DOCKET NO. 060658-EI

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that a true and correct copy of foregoing Rebuttal Testimony of Joseph A. Barsin has been furnished by U.S. Mail on this 6th day of March, 2007, to the following:

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INDEX OF EXHIBITS

REBUTTAL TESTIMONY—JOSEPH A. BARSIN

DOCKET NO. 060658-ei

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B & V CONTRACT	JAB-4	______
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RÉSUMÉ

Joseph A. Barsin
5500 Five knolls Drive
Charlotte, N.C. 28226
704-544-2564

Education

MDP Executive (1986), Northeastern University College of Business Administration (1986)
BS Marine Engineering (1964), State University of New York

Work Experience

2000- President and Chief Executive Officer, **Technocrats, Inc.** (Charlotte, NC) A technical consulting firm specializing in the areas of combustion, emissions, solid fuel ash management and technical editing

1996-2000 President and Chief Executive Officer, **Magaldi Corporation** (Charlotte, NC) Start up operation to activate and build the corporation to achieve long term profitable growth in the North America market.

1992-1996 Vice President, Operating Plant Services, **Kvaerner Pulping Inc.**(Charlotte, NC) Responsible for the financial and technical performance of the after market activity in the established Chemical Recovery business and for initiating and expanding Kvaerner's involvement in the North American Kraft (Black Liquor based) Cooking and Bleaching business

1990-1992 General Manager, Boiler Cleaning Equipment, **Diamond Power Specialty Company -** a subsidiary of Babcock and Wilcox (Lancaster Ohio). Responsible for the financial and technical performance of the base business, all markets, domestic and export.

1985-1990 General Manager, Industrial Projects, Service Division, **Babcock & Wilcox** Company (Barberton Ohio). Responsible for the technical and financial performance of upgrades, retrofits and repowering for all industrial markets including Pulp & Paper, Industrial, Petrochemical and Marine markets.

1983-1985 Product Line Manager, Fossil Fuel Systems, **Babcock & Wilcox**. Responsible for the technical and financial performance of the Combustion Systems, Fuel Preparation Systems, Material Handling Systems and Air Heater product lines.

1981-1983 Manager Engineering, Engineered Products, **Babcock & Wilcox.** Responsibilities broadened to include additional product lines. Fuel Preparation Systems, Material Handling Systems and Air Heater Systems were added to the engineering responsibility for Combustion Systems.

1975-1981 Manager of Combustion Systems Engineering Department, **Babcock & Wilcox.** Responsible for the research, design, and commercial application of burners and

1975-1981 combustors (hardware) for all fossil fuels. In addition, responsible for boiler fuel gas-side design standards, maintenance of the corporate-base fuel technology and the technology necessary to control NOx, CO, LOI, particulate emissions and slagging/fouling indexes.

1971-1975 Appointed Manager of the Mediterranean Field Engineering Region with responsibility for all **B&W** fossil fuel contracts in Eastern and Western Europe, the Middle East, and North Africa. Responsibilities included establishing an office in Milan, Italy; training engineers; commissioning new power plants; correcting design deficiencies; performance testing and collection of final payments; conceptualizing; and applying design updates for the retrofit market.

1964-1971 Joined **Babcock & Wilcox** in the Field Engineering Department. As a Service Engineer, responsibilities consisted of start-up, performance analysis, and design corrections on large pulverized coal-, gas-, and oil-fired utility steam generators both in the USA and abroad.
69-71 assigned to Barberton USA headquarters with responsibility for the coordination of engineered "fixes" developed, engineered and applied to correct field problems related to achieving predicted performance

Professional Affiliations

Member of the American Society of Mechanical Engineers (ASME). Chairman, (1984) Fuels Division. Past member of the Executive Board - Energy Conversion Group.

Member of the Technical Association of the Pulp and Paper Industry (TAPPI). Engineering Division Energy Management Committee, Past Chairman. **Presently, Engineering Division Chairman.**

Former Executive Committee Member of the Black Liquor Recovery Boiler Advisory Committee (BLRBAC).
Former member of the International Flame Research Foundation (IFRF)
Former member of the Council of Industrial Boiler Owners (CIBO), the American Boilers Manufacturers Association (ABMA), the EPA Advisory Board on Nox Emission Reduction, the DOE's Advisory Board on the Commercial Application of SYNGAS, the DOE's Advisory Board on Vision 2010 (Future Environmental/Energy Efficiency tradeoffs for USPulp/Paper, and the DOE's Advisory Board on Identifying R&D Opportunities in Pulping

Member the Board of Directors: Magaldi Corporation and Technocrats Inc.

Patents & Honors

Patent holder in the areas of combustion devices, and air pollution control.

Awarded George Westinghouse Silver Medal in 1986 by the American Society of Mechanical Engineers. The medal is bestowed for eminent achievement in the power field of Mechanical Engineering.

Elected to Fellow Grade by the American Society of Mechanical Engineers, 1993.
Best Paper Award-ASME-International Industrial Power Generation Conference 1987

Licenses

US Coast Guard Merchant Marine Officer-Third Assistant Engineer Steam and Diesel

Publications
please see attached pages labeled 2-4

Florida Power
CORPORATION

March 10, 1977

Black and Veatch
Post Office Box 8405
Kansas City, Missouri 64114

Attention: Mr. P. J. Adam

Subject: Florida Power Corporation Solicitation for Proposals to Perform Engineering and Associated Services

Gentlemen:

The Florida Power Corporation has recently decided to construct a new 600 Mw coal fired generating unit with provision for a future second unit on an existing site at Crystal River, Florida. This unit is scheduled for start of construction in October 1978 and for commercial operation in October 1982. It is planned that Florida Power Corporation will employ an Architect/Engineer to design the plant and will themselves perform procurement and construction management.

We invite you to submit your proposal for performing the Engineering services for this plant. Forwarded herewith, you will find two (2) copies of the listed documents for your use and guidance in preparing your proposal:

(a) Draft Contract - This document is a draft contract for A/E services.

(b) Project Description, Appendix A - This document supplies a general description of the site and the plant to be constructed.

(c) Form of Proposal - Specific responses requested for inclusion in your proposal.

It is requested your proposal be on a fixed price basis, supported by a description of the scope of services that will be provided for the price quoted.

If it is not your policy to quote fixed prices, proposals on other price basis will be accepted and evaluated provided they contain a base price, escalation terms and/or other base price adjustment terms and a scope of services to be provided for the quoted price.

If your proposal contains exceptions or comment on the content of this bid solicitation, please list these exceptions and comments separately and include adequate identification to the requirement to which they pertain.

It is required your proposal reach the undersigned on or before April 15, 1977, and that it be effective for a period of 120 days from bid due date.

In the event you have questions relative to this bid solicitation, please submit them in writing to the undersigned not later than March 21, 1977. The Florida Power Corporation's written response will be returned to you the week of March 28, 1977, or you may visit Florida Power Corporation during this week to discuss the Florida Power responses. If you wish to make a visit during the week of March 28, 1977, call the undersigned to arrange the time and place for meeting.

Florida Power Corporation, as a condition of this bid solicitation, reserves the right to reject all bids, or any bids.

Contact the undersigned relative to this bid solicitation at:

Florida Power Corporation
3201 - 34th Street South
Post Office Box 14042
St. Petersburg, Florida 33733

Telephone: (813) 866-4382

Sincerely,

John V. Maloney
Purchasing Manager

JVM/bdc

Enclosures

Florida Power
CORPORATION

April 11, 1977

Black and Veatch
Post Office Box 8405
Kansas City, Missouri 64114

Attention: Mr. P. J. Adam

Subject: Florida Power Corporation Solicitation for Proposals to Perform Engineering and Associated Services

Gentlemen:

In order to further clarify the desired scope of design services requested of the Architect/Engineer, and to further define the objectives of Florida Power Corporation for the construction of the 1982 Coal Unit, we offer the following supplemental information relative to this solicitation:

GENERAL INFORMATION

Bid Due Date

Florida Power Corporation wishes to advise the established bid due date has been extended. Bids from responding bidders are due on or before April 18, 1977, and are required to be effective for a period of 120 days from bid due date.

Exceptions and Qualifications

Bidder's exceptions or qualifications to the content of the bid solicitation must be submitted in writing with the proposal in order to receive consideration by Florida Power Corporation.

Payment Schedules

Payment schedules will be developed on a mutually agreeable basis with the selected bidder.

Aperture Cards

Florida Power Corporation will accept the standard aperture card that is normally used by the A/E. The information on the card shall be the same as shown on the drawing title block.

Florida Power Corporation - Resident Engineer

It is the intention of Florida Power Corporation to station a resident engineer at the design agency to enhance the interface between the A/E and Florida Power Corporation's engineering group. The individual selected will be knowledgeable and fully capable of handling the assignment.

Conceptual Cost of Proposed Plant

It is requested that a conceptual total cost of the plant proposed be included with your proposal.

FORM OF PROPOSAL

Quoted Prices

It was requested of the bidders in this solicitation that a fixed price for a defined scope of services be provided as alternate pricing which provided a base price and a description of the method to be employed for price adjustment. The alternate pricing proposal shall also include a defined scope of services offered.

The alternate pricing methods described by some bidders are considered to be satisfactory for evaluation purposes. It is the preference of Florida Power Corporation with alternate pricing quotations that total fee for services offered be included in the base price, instead of being assigned as a percentage of recoverable cost.

Replication/Duplication

Where reference to replication or duplication appears in this bid solicitation, it is not the intent of Florida Power Corporation to either replicate or duplicate another plant design in the full meaning of the word.

It is the intent of Florida Power Corporation that the A/E for bidding purposes, select and identify a plant which generally meets the technical parameters of the CR 4 coal-fired unit, with an output capability of 600 MW or somewhat less, as a base for their proposal.

The proposal shall consider and provide for modification of the base plant design, to accommodate equipment differences and characteristics which will result from equipment purchases made by Florida Power Corporation. All equipment purchases will be made through the competitive bidding process. It is desired by Florida Power Corporation that the A/E apply prior developments and available knowledge to the best advantage in the design of this plant to provide a high quality plant design at the lowest possible cost.

We have enclosed a CR 4 Design, Division of Responsibility which delineates the assignment of design responsibility for bidding purposes.

Modeling

Florida Power Corporation's requirements for modeling would be limited to the turbine front end piping.

Some bidders described other areas where in their judgment modeling may be beneficially utilized. In these instances, it is requested the bidders include in their proposal a description of the design areas for which they plan to make models and a narrative description of the benefits that would be provided by modeling. It will be satisfactory to quote separate prices for modeling.

Scheduling Methods

It is the desire of Florida Power Corporation to have the project schedule including the schedule for startup, testing, construction, procurement and design developed by the A/E and maintained with input from the Owner as required. The A/E shall maintain the schedule through the design phase and until the start of construction, at which time the maintenance of the project schedule will be assumed by the Owner.

Dependent on the scheduling methods employed by the A/E, it may be required that some sublevel scheduling be conducted to meet the described requirements.

Discussions of the interface of Florida Power Corporation's GPIS with the A/E's scheduling and cost estimating system developed that the system utilized by most A/E's is largely compatible with the GPIS. It is Florida Power Corporation's preference that the A/E submit a description of the scheduling system they plan to use and examples of the schedule reports they will supply. It is the intent of Florida Power Corporation to utilize the A/E's existing scheduling system to the highest degree possible, and requests only those changes which will make it possible to assume the maintenance of the schedule with a modified GPIS at a later date.

Florida Power Corporation will provide guidelines for coding of activities and established interfacing activities between project schedule components such as engineering, procurement, fabrication, licensing and construction. Each component may have the capability of being run independently or collectively.

Cost Reporting

With regard to cost reporting: Florida Power Corporation will require: (1) cost estimates by purchases and contracts as well as original cash requirements forecast consistent with the various schedules prepared by the A/E; and (2) a cost breakdown by Federal Power Commission accounts as well as the Florida Power Corporation Construction Chart of Accounts. The A/E will handle all cash requirements estimating until such time as the scheduling responsibility is transferred to Florida Power Corporation.

It is requested the A/E supply with their proposal a typical example of project estimate.

Standard Procedures

It is the intent of the reference to standard procedures in the form of proposal, to secure from the A/E a listing of typical procedures which are normally implemented for control of their projects and one or two examples of these typical procedures.

Standard Specifications

It is the intent of this reference in the Form of Proposal to solicit from the A/E several examples of specifications which are normally used on projects.

Standard Drawings

The form of proposal requests the A/E supply a list of standard drawings. This reference is intended to mean a listing of typical drawings such as electrical one-line diagrams, flow diagrams, general arrangement drawings, etc., which are normally developed for a coal unit.

System Description

The reference to system description in the form of proposal is intended to secure from the A/E an example of a typical system description which describes the design criteria, and operation of the system and the equipment which the system contains.

AGREEMENT

The following listed items pertain to the "draft" Agreement intent:

Contractor's Services, Engineering

We have developed a Division of Responsibility matrix which identifies the design activities and services and assigns responsibility for them to either Florida Power Corporation or the A/E. It is the intent of this document to further clarify the A/E scope of activity for bidding purposes.

Procurement Interface

For procurement, the A/E will supply the specification for soliciting bids, and will perform technical evaluations as requested, and will revise the specification after award and maintain the specifications for the duration of construction. Florida Power Corporation will supply the terms and conditions for the invitation to bid. They will also perform commercial evaluations, issue purchase orders and contracts, and administer these activities, including expediting and inspection as required.

Florida Power Corporation will expedite supplier design information and drawings. Purchase orders and contracts will provide for direct contact between contractors and suppliers for resolution of technical matters. Any technical changes which result in a change of the value of purchase orders or contracts must have prior approval by Florida Power Corporation and will be covered by purchase order or contract revisions.

Specifications

Specification format and content will be mutually agreed between Florida Power Corporation and the A/E. Spare parts requirements are to be included in specifications.

Preoperational Test Procedures

Preoperational test procedures will be developed by Florida Power Corporation.

Quality Assurance

It is expected the A/E will have a quality program for controlling the quality of their own performances.

Quality requirements for purchased equipment and services shall be included in the specifications.

Florida Power Corporation will perform all contractor and supplier quality assurance coverage as required.

Project Procedures Manual

Florida Power Corporation requires that one project procedures manual be developed for the project by the A/E including the Florida Power Corporation project activities. Florida Power Corporation will provide input as required covering their activities for development of the manual.

Performance Incentives

Florida Power Corporation is interested in performance incentives for the project design activities and requests that the bidders supply a description of an incentive program they consider appropriate for this application.

Commitments for Equipment and Services

Florida Power Corporation plans to make no commitment prior to January 1, 1978, for materials, equipment or services, other than A/E services and services for licensing and site exploration as required. It is requested that the A/E's supply the following information with their quote:

(a) With first commitment by FPC to suppliers January 1, 1978, what do you estimate will be the percentage of design completion in October 1978 at start of construction?

(b) On what date (latest) is suppliers design information required to have approximately 75% of design completed by October 1978 start of construction?

Site Liaison Engineering

Site liaison engineers supplied by the A/E's are expected to be knowledgeable, experienced people capable of interpreting designs and making on-the-job design decisions. It is expected the assigned people will be assigned responsibility for making design decisions to avoid the construction delays usually resulting from having to communicate design questions back to the design office for resolution. It is expected that an engineer will be required at the jobsite for only the period of activity of any given discipline, and for some period of time during startup and test.

Design Criteria - General Information

Plant shutdown facilities to provide for cold starts including steam line drains. For hot starts, a bypass system will be required. Ash pond is to be designed by A/E; a pump house and a recirculation system will be required.

CR 4 is intended to be a self-supporting plant and will require facilities for administrative offices and plant services.

Some freeze protection may be required, but this is minimal.

Fiberglass circulating water pipe will be considered for this unit.

Plant design planning shall be on the basis of two (2) units on a slide-along design. Control cable design for the second unit when designed would be uniquie for the unit. The following indicates those facilities that shall be sized for two (2) units:

Control Room
Ash Storage
Coal Handling
Cooling Tower Makeup & Blowdown System
Water Treatment
Personnel Facilities
Common Plant Services
(Service Air, Control Air, Light Oil, Potable Water, etc.)

Plant design criteria is to be developed at the start of design. Systems major and general requirements, including sizes, pressures, materials, and other parameters to be mutually developed. ASME codes and standards are to be used for design.

Cooling tower will be natural draft or mechanical draft, fresh water for bid purposes. It is anticipated that some studies in this respect will be required of the A/E. Cooling tower blowdown is also to be determined and will require study and recommendations by the A/E. Florida Power Corporation will provide makeup water supply to the site.

Turbine driven feed pumps shall be included. The feed pumps shall be on the operating floor unless such location interferes with turbine installation and access.

Coal bunkers shall be the silo type.

Precipitators to be of a side-by-side design to facilitate ash handling.

Coal unloading, rail and barge facilities now existing at Crystal River and servicing Units 1 and 2 are capable of supplying the new unit(s) and will not be supplemented. Coal blending facilities and conveyors over the existing intake and discharge canals shall be provided. The clearance height over the canals will be supplied by FPC at a later date.

Ash handling facilities shall include an ash pond and a silo for dry flyash storage.

Coal selection for design purposes will be supplied to A/E on or about May 1, 1977. For quoting purposes, the coal will be predominately Eastern coal with some blending of Western coal. Coal will be sized and washed at the mine and blending will be handled at the power plant. Recrushing will be performed at the power plant prior to pulverizing.

Sincerely,

JVMaloney

John V. Maloney
Purchasing Manager

JVM/bdc

March 29, 1977

Docket No. 060658-EI
RFP-March 10, 1977
Exhibit No. _____ (JAB-2)
Page 10 of 16

RESPONSES

TO

BLACK & VEATCH LETTER OF March 23, 1977

1. We feel a better definition of the scope of the coal handling facilities is needed. We assume a portion of the system will be designed by the Engineer and a portion will be designed by others under contract to your fuels subsidiary. The interface points need to be defined.

   You also mention beneficiation facilities. We need further definition of this. Are you considering an on-site wash plant or simply considering the necessary coal crushing and blending facilities?

   The existing barge unloader and proposed rail unloading systems for Units 1 & 2 will be used for unloading. All additional conveyors, stacker-reclaimers, crushers, scales, etc., will be designed by the A/E.

   We do not have a coal yet, but plan to have a range of coal parameters by May 1, 1977; therefore, we cannot advise you precisely what beneficiation facilities are required. For proposal purposes, consider only the necessary blending and crushing facilities.

2. The interface between FPC and the Engineer for purchasing activities should be defined.

   a. Will FPC require conformed specifications and contracts after the purchase is completed?

      FPC will perform the purchasing and will require conformed bilateral purchase orders and contracts after the purchase is completed.

   b. If we must evaluate unpriced proposals, will we be required to evaluate all proposals or will FPC do a preliminary screening and eliminate those bidders obviously not in contention from a price standpoint?

      FPC will perform a preliminary screening of proposals from bidders and will notify the A/E of those technical proposals to be evaluated.

3. The interface between FPC and the Engineer on scheduling and cost reporting activities should be defined?

   a. Will FPC, through use of its GPIS system, handle overall project scheduling? We would anticipate running our management control schedule and detailed engineering schedules for internal project control and providing input to the FPC GPIS system. Is our assumption correct?

      Yes, Florida Power will provide guidelines for coding of activities and established interfacing activities between project schedule components such as engineering (design, specs., drawings, studies), procurement, fabrication, licensing and construction. Each component may have the capability of being run independently or collectively.

   b. On cost reporting, we assume you will need cost estimates by purchases and contracts and, in addition, a breakdown by FPC accounts. We further assume that you will monitor actual cost performance against the estimates and will handle all cash flow estimating and cash flow reporting. Are our assumptions correct?

      With regard to cost reporting for the project, Florida Power Corporation will require: (1) cost estimates by purchases and contracts as well as original cash requirements forecast consistent with the various schedules prepared by the A/E; and (2) a cost breakdown by Federal Power Commission accounts as well as the Florida Power Corporation Construction Chart of Accounts. The A/E will handle all cash requirement estimating until such time as the scheduling responsibility is transferred to Florida Power Corporation. It is our intention that Florida Power Corporation handle cost reporting for the project.

4. We would plan to have design packages 100 percent complete prior to construction as you require, assuming FPC decision making and purchasing is accomplished in a timely manner to enable us to do this.

   You have also required 75 percent overall completion of engineering by October 1, 1978. We don't believe this is necessary since the work would be done in packages and there could be as much as two years' time lapse between the first construction package and the last construction package. Further, we feel that it will not be possible for you to make decisions and complete purchases rapidly enough to permit engineering to be 75 percent complete by October 1, 1978. We would submit a bar chart schedule with our proposal showing the approximate schedule for engineering and the interface with construction packages so that engineering could be 100 percent complete on a given construction package prior to award of that contract.

   We required 75 percent completion of design before start of construction based on the assumption that this plant, to a large extent, would be an adaptation of an existing design suitable for FPC's selection of major equipment. Our objective is to have as much design completed as possible before the start of construction.

5. With regard to your proposed contract Article II, Item E, we would like to have you further define the amount of site liaison engineering you require since this is to be included in the fixed price. On our previous assignments for FPC, you have not found it necessary to have us furnish resident engineers in order to interpret our plans and specifications.

   It is the intent of Article 11, E, that Site Liaison Engineers are required and would include one per principal discipline, i.e., civil and/or civil/structural, mechanical, electrical and instrumentation/control in residence on site during each respective phase of the work.

6. With regard to your proposed contract Article IV, A, should Item 1, Procedures Manual, also be included as a part of the fixed price? We feel it should be.

   The Project Procedures Manual should be included in the scope of fixed price work. All project related interfaces within the A/E and the FPC organization are to be included.

7. With regard to your proposed contract Article V, A, we would like to suggest that progress payments be based on a schedule developed from estimated manpower assignments over the duration of the project rather than equal monthly payments for a mutually agreed period. We would like to discuss this with you.

   We will be happy to discuss the payment scheme for the A/E contract, however, Florida Power Corporation strategy should consider:

   a. The cost of money implicit in any agreement.

   b. Inclusion of as much work as can be properly defined and managed in the fixed price scope.

   c. No significant "prepayment" for A/E services over the life of the contract.

   d. Some incentive to perform according to the provision of the contract or a penalty for non-performance.

8. Proposed contract Article V, B, would need to be adjusted to reflect our standard accounting month which runs from the 27th to the 26th. Would this be acceptable?

   Florida Power Corporation has no compelling reason to reject this proposal so long as the establishment of a stable billing/payment cycle is not impaired and budgetary controls are not compromised.

9. We would like further definition of your requirements for information under Items 16 through 20 of your FORM OF PROPOSAL.

   (16) What are your project control methods?

   (16) This question is intended to provide for you the opportunity to present the methods used in your activities to control design, schedule costs, etc., and to provide examples of these control tools as you may elect.

9. We would like further definition of your requirements for information under Items 16 through 20 of your FORM OF PROPOSAL.

(16) What are your project control methods?

(16) This question is intended to provide for you the opportunity to present the methods used in your activities to control design, schedule costs, etc., and to provide examples of these control tools as you may elect.

(17) What standard procedures do you have available for application to this project?

(17) We are providing in this item an opportunity for the bidders to present a listing of standard project procedures which are normally implemented on their projects. Your response to this question may be a listing of procedures and examples from a past or present project, or a narrative description of procedures, whichever you may elect to provide.

(18) Supply a listing of the standard specifications you would utilize for this project. Provide several typical examples.

(18) This item is intended to secure from bidders a listing of specifications which are normally developed for a coal unit.

(19) Supply a listing of the standard drawings you plan to utilize for this project.

(19) The standard drawings referenced in this item may be included but not limited to:

(a) Typical electrical one-line diagrams
(b) Typical flow diagrams
(c) General arrangement drawings

This item is intended to secure from bidders a listing of drawings which are normally developed for a coal unit.

(20) Systems Description

(20) This item requires that system descriptions be prepared for all systems and major equipment. These descriptions are to contain the operation and design of the systems in sufficient detail so that operating personnel can become familiar with the equipment and systems and to be used in the development of operating and maintenance procedures.

APPENDIX A
PROJECT DESCRIPTION
CRYSTAL RIVER #4

INTRODUCTION

Florida Power Corporation (Owner) plans to build a new generating facility at the present Crystal River plant site consisting of one unit rated at approximately 600 MW with provision for a future second unit. The unit is to be coal-fired, single reheat steam turbine driven with throttle conditions of 2,400 psig, 1,000/1,000°F. The Crystal River plant site currently has two existing fossil-fired steam generating units and one nuclear generating unit. It is expected that the fuel to be burned will be bituminous coal which will meet the specified environmental requirements for sulfur emissions.

The planned construction start date for the new generating facility is October 1, 1978, and commercial operation is scheduled for October 1, 1982.

This document describes the plant to be constructed and outlines the necessary engineering work to be performed by the Architect-Engineer (Contractor). The applicable environmental regulations of the Florida Department of Environmental Regulation, the Federal Environmental Protection Agency, the U.S. Corps of Engineers, and the Coast Guard must be met in the design of this plant.

Currently the plant site has intake and discharge canals. These canals are to be used for fuel delivery for the new generating facility layout. Utilization of the intake canal and extending the existing coal handling facilities must be accomplished to accommodate the new generating units.

UNIT ORIENTATION

The unit will be oriented on the plant site to take advantage of the existing substations. The units will also be located so that effective use is made of the available land for the cooling water system. The unit orientation must also take into consideration the existing intake canal and fuel handling equipment.

SITE ACCESS

An extension from the existing railroad spur and a new access road from U.S. Highway 19 are to be provided. Good access to the site by rail and highway is desirable to minimize the delivery costs of equipment and material used in construction of the plant.

SUBSTATION

The existing substations at Crystal River Plant will be expanded for the new units. A short transmission corridor will be required from the new units to the existing substation. This corridor will be located on Florida Power property. The substation design will be by the Owner with interfaces by the Contractor.

SCOPE

The Contractor shall provide the engineering and design and associated services for an approximate 600 MW coal-fired steam turbine driven electric generating unit with provision for a duplicate future unit to be located at Red Level, Florida.

GENERAL DESCRIPTION

The unit is to consist of a single boiler supplying steam to a tandem compound single reheat turbine generator unit designed for operation at 2,400 psi steam pressure at the turbine throttle. Main and reheat steam temperature will be 1,000°F. The unit is to be designed to operate at 5 per cent over pressure (2,520 psi) conditions continuously without time limit considerations because of equipment limitations. The unit shall be designed for cyclic operation.

The unit is to be designed to burn coal that will enable the stack discharge to meet Federal, State, and Local air compliance requirements without the use of backend sulfur removal equipment. The design must provide space for the addition of sulfur removal equipment in the future.

An electrostatic precipitator is to be installed for flyash removal.

BOILER

The boilers shall be capable of burning a wide range of coals. The fuel to be burned will be determined later.

ASH HANDLING

The bottom ash handling system shall be a wet system utilizing recirculated fresh water with makeup from wells and/or cooling tower blowdown. The ash storage facility must meet the environmental requirements of the State of Florida and the federal agencies.

FLYASH HANDLING AND STORAGE

The flyash handling system shall be a dry flyash system utilizing silos for offsite disposal of flyash. Facilities to load the flyash into trucks and/or railcars must be provided.

TURBINE GENERATOR

The turbine generator shall be tandem compound, single shaft, single reheat, four flow exhaust, 3,600 rpm with optimized feedwater heating, one stage of which will be a deaerator.

FUEL SYSTEM

The fuel unloading system is to be integrated with the existing system installed for Crystal River Units 1 and 2. The fuel will be unloaded from barges and/or trains and conveyed to the new units. A surge pile will be installed at the new units. All necessary conveyor belts transfer stations, reclaim systems, crushers, trippers, coal silos, coal sampler, and scales shall be included. Coal blending and beneficiation facilities are included.

Coal is to be stored in an area adjacent to the Crystal River 1 and 2 coal storage area. The coal storage area is to contain a 90-day fuel supply at a 75 per cent use factor.

An oil storage tank will be provided for light oil to be used for ignition, warm-up, and flame stability.

CONDENSER COOLING WATER

The unit will be equipped with a cooling tower and closed cycle condenser cooling system. Make up water to the cooling towers will be fresh water obtained from new wells, the Withlacoochee River, and/or the Crystal River. A condenser optimization study will be performed to determine the optimum arrangement of condenser and cooling water system.

CHIMNEYS

The flue gases from each unit will be discharged to a separate concrete chimney. The chimneys will be lined with alloy steels and/or stainless steels capable of withstanding the corrosive atmosphere from the flue gases for the life of the plant.

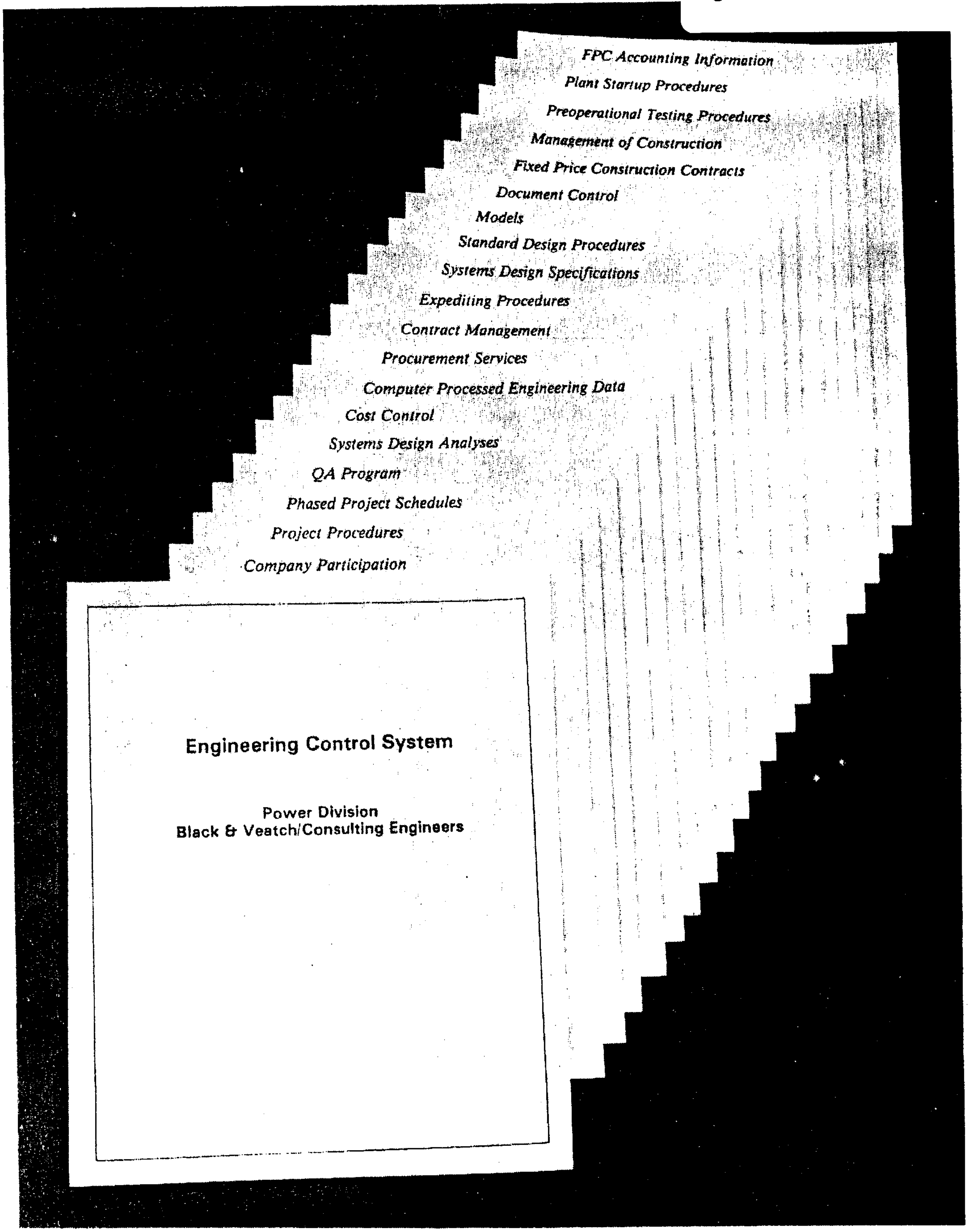
BUILDINGS AND STRUCTURES

The turbine generator and steam generator will be enclosed. Service building or buildings will be provided containing administrative offices, maintenance shops, chemical laboratory, storerooms, and personnel facilities. Site improvements and facilities will be included as required for a complete installation.

Water treatment equipment will be located in a separate auxiliary building.

WASTE WATER

Waste water from water treating equipment, metal cleaning, sanitary systems, boiler blowdown, coal pile runoff, will be treated and discharged in accordance with State and Federal regulations.


FPC Accounting Information
Plant Startup Procedures
Preoperational Testing Procedures
Management of Construction
Fixed Price Construction Contracts
Document Control
Models
Standard Design Procedures
Systems Design Specifications
Expediting Procedures
Contract Management
Procurement Services
Computer Processed Engineering Data
Cost Control
Systems Design Analyses
QA Program
Phased Project Schedules
Project Procedures
Company Participation
Engineering Control System
Power Division
Black & Veatch/Consulting Engineers

THIS DOCUMENT IS CONFIDENTIAL BETWEEN BLACK & VEATCH AND FLORIDA POWER CORPORATION FOR UNRESTRICTED INTERNAL USE BY FPC IN SELECTING A DESIGN ENGINEER FOR THE 1982 UNIT.

Florida Power Corporation
Crystal River Unit No. 4

April 15, 1977
FPC File No. PPC-747

We appreciate very much your invitation to present this Proposal and hope that it is acceptable to you. We would like to discuss the details further with you at your convenience.

We are very interested in this Project and will do our best to make it an outstanding one.

Very truly yours,

BLACK & VEATCH

Riley D. Woodson
Executive Partner
Head of Power Division

tb

BLACK & VEATCH
CONSULTING ENGINEERS

TEL. (913) 967-2000
TELEX 42-6263

1500 MEADOW LAKE PARKWAY
MAILING ADDRESS: P.O. BOX NO. 8405
KANSAS CITY, MISSOURI 64114

Florida Power Corporation
Crystal River Unit No. 4

April 15, 1977
FPC File No. PPC-747

Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

Attention: Mr. J. V. Maloney
Purchasing Manager

Gentlemen:

In accordance with your invitation dated March 10, 1977, we hereby submit our Proposal for Engineering Services for your proposed 600 megawatt Crystal River Plant Unit No. 4 scheduled for 1982 commercial operation. This unit is to be coal fired and separated from existing units on the site. Our Proposal information attached hereto responds directly to your Request for Proposal and is intended to include the complete Scope of Services you have specified as required for the Project. A discussion of fees and related matters is set forth in a separate letter.

We have described herein generally the scope of the Project and the Scope of Services to be performed and have indicated our approach to providing the required services so that a project of high quality and the lowest feasible cost will be accomplished.

We have extensive experience in the design of a number of similar projects in the general size contemplated. Furthermore, we have ample engineering manpower to accomplish this Project as scheduled. We propose to apply to this Project our current experience for similar units.

TABLE OF CONTENTS

SECTION I

INTRODUCTION

I. INTRODUCTION

This Proposal has been prepared by Black & Veatch (Engineer) in response to the Florida Power Corporation (Owner) letter dated March 10, 1977, inviting proposals for Engineering Services in connection with the design and construction of Crystal River Unit 4.

Black & Veatch has in-house capability to provide all Engineering Services required for the project. Equipment and materials would be supplied to the Owner by manufacturers and suppliers. Construction would be performed by qualified contractors under fixed price contracts with the Owner, and such contracts would be prepared by the Engineer.

It is our intent to be as responsive as possible to your Request for Proposal and proposed Contract/Agreement bound herein. We are in general accord with your Request for Proposal insofar as it relates to Engineering Services. Our comments on the proposed Contract/Agreement bound in Section VIII relate primarily to maintaining, for the Owner and the Engineer, the full protection afforded by our professional liability insurance. In addition, we are proposing alternative terms of payment which are compatible with our standard method of billing.

The Black & Veatch Engineering Control System, which was described to Florida Power Corporation personnel during a presentation in St. Petersburg on March 29, 1977, would be utilized to the full extent consistent with your own internal management system. Replication of features of other units we have designed will be utilized to the extent practicable, without interfering with the objective of a reliable low cost unit. It is not our intent to restudy design decisions which are well known as a result of our work on other units.

Information requested by FPC can be found in our letter of transmittal and in the following sections of the Proposal.

I. Introduction

II. Suggested Project Description

III. Cost Estimate

IV. Scope of Engineering Services

V. Supplementary Information

   1.0 Rates and Charges
   2.0 Replication

SECTION II

SUGGESTED PROJECT DESCRIPTION

II. SUGGESTED PROJECT DESCRIPTION

The following is a suggested description of the project based on our understanding of the requirements and on Appendix A, Project Description.

1.0 LOCATION AND ARRANGEMENT

Crystal River Unit 4 is to be located north of the existing Crystal River Plant. Site planning is to also provide space for a future duplicate unit at the new location.

The arrangement of the proposed Unit 4 will include the following major elements.

- Main building complex, including the turbine-generator building and the steam generator and accessory equipment.
- Coal handling and storage facilities, including space for the active coal pile.
- Combustion gas cleaning facilities.
- Cooling tower makeup water intake and blowdown discharge structures.
- Ash storage facilities.

Railroad access will be provided to the Unit 4 turbine room and boiler area, with the railroad spur track entering the plant area from the east.

Ash storage bins and the ash pond will be located near the main plant loop access road. The ash storage facilities will include provisions for truck haulage of the fly ash to a permanent storage area or for commercial sales.

The existing 230 kV substation facilities will be modified by the Owner for connection to the Unit 4 main generator transformer and to the startup transformer which would be common to Unit 4 and future Unit 5.

Water pretreatment and sewage treatment facilities will be sized to serve Unit 4 and future Unit 5.

Machine shop and office facilities will be provided adjacent to the main generation building of Unit 4. A new vehicle and heavy equipment maintenance building will be provided in the coal yard area near the existing coal yard maintenance and crusher buildings. These facilities will be sized to accommodate the personnel and maintenance requirements of both Unit 4 and future Unit 5.

2.0 SITE AND STRUCTURES

The exterior appearance of the Unit 4 building structures will be similar to existing coal-fired units at the site. The turbine-generator and steam generator will be fully enclosed. Interior finishes and partition wall construction in all major structures will be comparable to existing buildings.

2.1 **Main Building Structures.** Unit 4 and future Unit 5 will be arranged adjacent and connected to each other. There will be a common turbine room for both units with the turbine-generators arranged on the same longitudinal axis.

A control room will be located adjacent to the turbine room at the operating floor elevation in the space between Unit 4 and future Unit 5 steam generators.

The coal silos and pulverizers will be arranged along both sides of the boiler.

The control wing will be insulated and air conditioned. The remaining enclosed portions of the generation building will be ventilated with gravity roof ventilators, wall louvers, and local ventilation fans.

Vertical access will be provided by a minimum of two stairways to each major area and one utility elevator located in the auxiliary bay of the generation building.

An overhead turbine room crane will be provided to handle turbine-generator components and auxiliary equipment. Other necessary hoists and hoist systems will be provided as required to enable plant and maintenance personnel to handle and maintain materials and equipment components.

2.2 **Foundations.** The foundations for the Unit 4 facilities will be similar in design to the foundations used for existing coal-fired units at the site.

The foundation for the steam-generator, turbine-generator, and control wing will be a concrete mat or raft supported on compacted fill. Similar mat type foundations will be provided for the chimney and any other heavily loaded structures.

Lighter weight structures such as precipitators, ductwork, and office, shop and warehouse buildings will have drilled pier or spread footing foundations under all support columns.

2.3 **Site Preparation, Roads, and Railroad Tracks.** Site preparation will consist primarily of grading and fill operations to raise the general site elevation to approximately 98 feet, plant datum (PD).

Fine grading and landscaping will be provided for effective drainage to hold up impoundments where required and to existing waterways.

Access to the central generating complex will be provided by a loop road around the generation building connecting to a new access road entering from U.S. Highway 19 on the east. The access and loop roads will be comparable in construction to the existing main site access roads. Secondary roads will be provided for access to the expanded coal yard areas, the cooling water intake and blowdown structures, the substation area, and ash disposal areas.

Railroad spur tracks will be extended to the boiler and turbine areas and to the construction laydown area. The spur tracks will connect with the existing railroad track entering the general site area from the east.

3.0 MECHANICAL EQUIPMENT AND SYSTEMS

3.1 Turbine-Generator. The turbine-generator will be a tandem compound, four flow, single reheat, 3600 rpm unit with 30 inch last stage blading, or equivalent annulus area.

The turbine-generator will be rated at 640,000 kW* when operating at nominal steam conditions of 2400 psig, 1000 F, reheat to 1000 F, while exhausting at 2.0 inches Hg absolute back pressure, 0 per cent makeup, and while extracting for normal feedwater heating and boiler feed pump operation.

The turbine will be designed to operate satisfactorily at 105 per cent nominal throttle pressure (2520 psig, 1000 F/1000 F) with valves wide open and 1.5 inches Hg absolute back pressure. The expected turbine capability at this condition will be approximately 700,000 kW.* The steam-generator and all auxiliary equipment will be designed for continuous operation at this condition.

The generator kVA rating will be based on the turbine capability at 105 per cent nominal throttle pressure and valves wide open with 0.90 power factor.

3.2 Steam Generator. The steam generating unit will be a pulverized coal-fired, drum type, balanced draft unit equipped with economizer and regenerative air heaters. The steam generator will be top supported.

*Approximate rating. Final rating to be specified by Florida Power Corporation.

The unit will be designed for safe and reliable operation from 25 per cent of rated capacity to maximum capability. The steaming capacity of the unit will be as follows.

Superheater Outlet	Rated Capacity	Maximum Capability
Steam Flow, lb per hour	4,500,000	4,750,000
Pressure, psi	2,500	2,620
Temperature, F	1,005	1,005

Fuel firing equipment will include sufficient pulverizers to supply the unit at maximum capability when firing a range of low sulfur coals. The unit will be capable of operating at maximum capability with worn pulverizers and one pulverizer out of service.

The furnace will be designed for continuous operation at maximum capability without excessive slagging. An air soot blowing system will be provided with an automatic sequential type control system incorporating variable group control for selecting individual or groups of blowers.

Two primary air fans, two forced draft fans, and four induced draft fans will be used for combustion air and gas handling.

Rotary regenerative type air heaters will be used to preheat the primary and secondary combustion air. Air preheat coils will be provided as required to prevent cold end corrosion of the regenerative air heaters.

3.3 Coal Handling. The existing coal yard and receiving facilities will be expanded and modified to accommodate the increased tonnages of coal to be received, stored, and processed for the two existing units, Unit 4 and future Unit 5. The following major elements are anticipated to be required.

(1) A stacker-reclaimer for movement of coals into and out of service storage as required by plant fuel consumption. The machine will be similar in design concept to the stacker-reclaimer of the present coal facilities with modifications to incorporate advances in technology. The stacker-reclaimer will be rated at 3000 tons per hour (stockout), 1600 tons per hour (reclaiming and bypassing) and will service an active storage volume of 54,000 tons with minimal usage of supplemental dozing or haulage equipment.

(2) Crusher facilities designed for reduction of mine run coal to a 1 1/2 x 0 product suitable for feed to the pulverizers of the steam-generator. The crusher facilities will be housed in an enclosed structure located approximately 2300 feet to the west and slightly south of the present crusher house. The facilities will essentially duplicate design concepts and arrangement of the existing crusher facilities and will include dual crushers (each rated at 800 tons per hour), drive motors, feed and surge storage equipment, and sampling system.

(3) A dual conveyor system, including associated supporting structures, will be used between the stacker-reclaimer and the silo filling system of the Unit 4 central generation facilities. Each conveyor will be similar in design and construction to the existing equipment. The dual conveyor system will be rated at 1600 tons per hour (800 tons per hour per belt) with the 42 inch belt operating at about 450 feet per minute. Surge storage volumes will be provided at the transfer points between belt flights.

(4) A single belt, cascade type silo filling system above each row of silos flanking the Unit 4 steam-generator. Each system will be rated at 800 tons per hour.

(5) Coal dust collection systems consisting of bag filter type units at the crusher and silo fill areas and at all transfer points. The system will include manifolded collection piping for dust pick-up at all major points of generation.

(6) Personnel facilities (offices, locker rooms, etc.) for the additional manpower required by the expanded coal yard operations.

(7) A maintenance facility to serve the coal yard including maintenance of coal handling mobile equipment.

It is assumed that the following major elements will be provided by the fuels contractor (Electric Fuels).

(1) All coal unloading and receiving facilities including crosstie conveyor links to the existing barge unloading facilities.

(2) Site filling and improvements for expansion of the reserve storage capabilities of the coal yard and for control of coal yard rainfall runoff.

(3) Mobile equipment required for stockout of coal to reserve storage and for pile management.

3.4 Air Quality Control System. Electrostatic precipitators will be provided for compliance with both Florida and federal regulations regarding allowable levels of particulate. The precipitators will be hot or cold side precipitators arranged in four separate units, each about 125 feet wide, 55 feet long, and 60 feet high including hoppers. Gas velocity through each precipitator unit will be 4.5 feet per second or less. The specific collecting area for a hot precipitator will be about 450 square feet of collecting surface per 1000 acfm at maximum load. For a cold precipitator 700 square feet of specific collecting area will be provided. Approximately 45,000 pounds of fly ash per hour will be collected at maximum load. About 3.5 MW of transformer-rectifier power will be installed.

3.5 Chimney. There will be one chimney per unit. The Unit 4 chimney will be approximately 700 feet high and will be constructed with a steel liner or independently supported brick liner surrounded by a concrete shell.

3.6 Condensate and Boiler Feed Pumping Systems. Pumping of condensate will be accomplished by the use of two half-capacity condensate pumps. Each pump will be capable of maintaining approximately 75 per cent rated load with the other pump out of service.

Dual half-capacity or a single fill capacity turbine driven boiler feed pump will be used for pumping the feedwater from the deaerator through the high pressure feedwater heaters and economizer to the steam generator drum. The capacity of the pump(s) will be regulated by varying the speed of the drive turbine(s).

3.7 Feedwater Heating System. Feedwater heating will be accomplished with seven or more stages of feedwater heating including an open deaerating heater.

The heater drains system will be a cascade type arrangement. The high pressure heater drains will be cascaded to the deaerator. A high pressure drains pump will be provided for pumping the drains at low loads. The low pressure heater drains will be cascaded through the low pressure heaters and returned to the condensate system by a single full capacity low pressure heater drain pump.

3.8 Ash Handling and Storage. Bottom ash will be collected in an independently supported, water sealed, and water impounded ash hopper. A dual-line sluicing system will be utilized for conveying the bottom ash to an ash pond located adjacent to the plant access road. Sluice water will be recycled using pumps located in a pump house adjacent to the ash pond.

The pyrites collection system will consist of small collection hoppers connected to the pyrites discharge outlets from each pulverizer. The collection hoppers will be emptied sequentially and the pyrites conveyed to an intermediate pyrites storage tank. The storage tank will be periodically emptied by the bottom ash conveying system on a time shared basis.

Fly ash from the economizer hoppers and any gas duct hoppers will be continuously collected in water-filled hoppers and sluiced to the intermediate pyrites storage tank.

The precipitator fly ash will be collected and stored dry to allow for commercial sales or disposal by landfill techniques. The precipitator fly ash will be collected by a vacuum system and conveyed to a transfer tank. A positive pressure system will be used to pneumatically convey the fly ash from the transfer tank to a storage silo (one silo per unit) located near the main plant access road. The storage silo will be equipped with a dry unloading spout and two rotary dustless unloaders and will be sized for three days accumulation of fly ash.

3.9 **Circulating Water System.** The cooling system for Unit 4 will utilize a closed-cycle circulating water system with natural draft towers.

The major components of the natural draft tower system include makeup water intake and blowdown discharge structures, circulating water piping, cooling tower, condenser and auxiliary cooling water system. These components are outlined below.

3.9.1 **Intake and Discharge Structures.** A common two unit intake structure, located on the Withlacoochee and/or Crystal River will be required for the natural draft cooling tower system. The structure will be approximately 20 feet wide per unit and will be divided into two inlets each equipped with a full capacity pump. Either pump will be capable of supplying the unit makeup requirements. A traveling screen will be located at each inlet. Stop logs will be provided to permit each bay to be isolated and drained as required. Trash racks located ahead of the intake screens will be designed to prevent heavy trash and debris from coming in contact with the screens. The intake structure will also house high pressure screen wash pumps which will supply spray water for both present and future traveling screens.

As an alternative, the cooling tower makeup water could be supplied from wells.

The discharge structure for tower blowdown will be located on the river downstream from the intake or on the north bank of the existing discharge canal. The structure will employ a single head wall and stilling basin design concept.

3.9.2 Circulating Water Pipe. The circulating water flow rate for the natural draft cooling tower heat dissipation system will be about 304,000 gpm which will require one 108-inch FRP pipe to circulate water between the cooling tower and the unit condenser. Each pipe will be about 500 feet long and will be placed in a trench at a depth of 3 to 5 feet below grade.

The cooling tower makeup piping will be approximately 48 inches in diameter. The blowdown piping will be approximately 54 inches in diameter and will be routed from the tower basin to the river or to the discharge canal. Pipeline routing will accommodate parallel installation of additional pipelines for future Unit 5.

3.9.3 Cooling Tower. The cooling tower will consist of one natural draft cooling tower for Unit 4 located approximately 400 feet from the central plant complex. The tower will be designed to dissipate 3300×10^6 Btu per hour with a range of 22 F, 79 F wet bulb and an approach of 14 F. The approximate tower dimensions will be 400 feet high and 325 feet in diameter at the base.

3.9.4 Condenser. The main condenser will consist of dual two pass surface condensers with a total surface area of 400,000 square feet. The condenser will be designed to remove 3300 by 10^6 Btu per hour while operating under peak load conditions.

3.9.5 Auxiliary Cooling Water Systems. Water will be supplied to the auxiliary cooling water system heat exchangers via the makeup water system and will be discharged to the cooling tower for use as tower makeup water.

3.10 Fire Protection Systems. The basic planning for fire protection will include the following systems.

Equipment or Area Protected	Type of Protection
Yard and Building Exteriors	Fire hydrants and hose houses
Building Interiors	Fire extinguishers and hose cabinets
Control Room and Electrical Equipment Rooms	Fire extinguishers and smoke detection devices
Turbine Generator	Carbon dioxide hose stations
Major transformers and Lubricating Oil Equipment	Water fog systems
Coal Conveying System	Water sprinkler systems

The service water and fire water systems will be interconnected. Initial fire water demand will be provided by the service water head tank. Additional fire water demand will be provided by a fire pump taking suction from a new 1,000,000 gallon treated water storage tank provided for service water storage.

4.0 ELECTRICAL EQUIPMENT AND SYSTEMS

4.1 **Generator.** The generator will be rated 0.90 power factor, 0.50 short circuit ratio, and will be designed in accordance with industry standards.

The excitation system will be shaft driven and will have a nominal response ratio of 0.5.

The generator rotor will be hydrogen cooled; stator windings will be water cooled or hydrogen cooled.

Generator stator winding surge protection equipment will consist of lightning arresters and capacitors mounted in isolated phase type compartments. Three sets of potential transformers will be used for voltage regulation, metering, and relaying. One set of potential transformers will be calibrated for high accuracy metering for performance calculations.

The generator neutral will be bused together and connected to a distribution type neutral grounding transformer and secondary resistor mounted in a metal enclosed compartment.

4.2 **Generator Main Leads.** The generator main leads will be connected to the generator transformer, main auxiliary transformer, potential transformers, and surge protection equipment using 110 kV BIL or 150 kV BIL isolated phase bus duct depending on the nominal voltage rating of the generator. The main bus will be designed for forced air cooling; bus taps will be self-cooled.

4.3 **Generator Transformer.** The generator transformer will be designed for 3-phase, 60 hertz, FOA cooling class operation and will have a kVA rating at 65 C temperature rise consistent with that of the generator. High voltage windings will be connected wye and solidly grounded; low voltage windings will be connected delta.

4.4 **Auxiliary Electrical System.** One full capacity main auxiliary transformers with two secondary windings will serve the auxiliary electrical system. The primary winding will be connected to the generator main leads. Each secondary winding will serve one of two 7.2 kV switchgear buses. Each switchgear bus will utilize breakers having an interrupting rating of 500 MVA.

CONTRACT/AGREEMENT
FOR
ENGINEERING SERVICES
BETWEEN

FLORIDA POWER CORPORATION
AS OWNER

AND

____
CONTRACTOR

Florida Power
CORPORATION

March 10, 1977

Black and Veatch
Post Office Box 8405
Kansas City, Missouri 64114

Attention: Mr. P. J. Adam

Subject: Florida Power Corporation Solicitation for Proposals to Perform Engineering and Associated Services

Gentlemen:

The Florida Power Corporation has recently decided to construct a new 600 Mw coal fired generating unit with provision for a future second unit on an existing site at Crystal River, Florida. This unit is scheduled for start of construction in October 1978 and for commercial operation in October 1982. It is planned that Florida Power Corporation will employ an Architect/Engineer to design the plant and will themselves perform procurement and construction management.

We invite you to submit your proposal for performing the Engineering services for this plant. Forwarded herewith, you will find two (2) copies of the listed documents for your use and guidance in preparing your proposal:

(a) Draft Contract - This document is a draft contract for A/E services.

(b) Project Description, Appendix A - This document supplies a general description of the site and the plant to be constructed.

(c) Form of Proposal - Specific responses requested for inclusion in your proposal.

General Office 3201 Thirty-fourth Street South • P O. Box 14042, St Petersburg, Florida 33733 • 813—866-5151

It is requested your proposal be on a fixed price basis, supported by a description of the scope of services that will be provided for the price quoted.

If it is not your policy to quote fixed prices, proposals on other price basis will be accepted and evaluated provided they contain a base price, escalation terms and/or other base price adjustment terms and a scope of services to be provided for the quoted price.

If your proposal contains exceptions or comment on the content of this bid solicitation, please list these exceptions and comments separately and include adequate identification to the requirement to which they pertain.

It is required your proposal reach the undersigned on or before April 15, 1977, and that it be effective for a period of 120 days from bid due date.

In the event you have questions relative to this bid solicitation, please submit them in writing to the undersigned not later than March 21, 1977. The Florida Power Corporation's written response will be returned to you the week of March 28, 1977, or you may visit Florida Power Corporation during this week to discuss the Florida Power responses. If you wish to make a visit during the week of March 28, 1977, call the undersigned to arrange the time and place for meeting.

Florida Power Corporation, as a condition of this bid solicitation, reserves the right to reject all bids, or any bids.

Contact the undersigned relative to this bid solicitation at:

Florida Power Corporation
3201 - 34th Street South
Post Office Box 14042
St. Petersburg, Florida 33733

Telephone: (813) 866-4382

Sincerely,

John V. Maloney
Purchasing Manager

JVM/bdc

Enclosures

Florida Power
CORPORATION

April 11, 1977

Black and Veatch
Post Office Box 8405
Kansas City, Missouri 64114

Attention: Mr. P. J. Adam

Subject: Florida Power Corporation Solicitation for Proposals to Perform Engineering and Associated Services

Gentlemen:

In order to further clarify the desired scope of design services requested of the Architect/Engineer, and to further define the objectives of Florida Power Corporation for the construction of the 1982 Coal Unit, we offer the following supplemental information relative to this solicitation:

GENERAL INFORMATION

Bid Due Date

Florida Power Corporation wishes to advise the established bid due date has been extended. Bids from responding bidders are due on or before April 18, 1977, and are required to be effective for a period of 120 days from bid due date.

Exceptions and Qualifications

Bidder's exceptions or qualifications to the content of the bid solicitation must be submitted in writing with the proposal in order to receive consideration by Florida Power Corporation.

Payment Schedules

Payment schedules will be developed on a mutually agreeable basis with the selected bidder.

Aperture Cards

Florida Power Corporation will accept the standard aperture card that is normally used by the A/E. The information on the card shall be the same as shown on the drawing title block.

Florida Power Corporation - Resident Engineer

It is the intention of Florida Power Corporation to station a resident engineer at the design agency to enhance the interface between the A/E and Florida Power Corporation's engineering group. The individual selected will be knowledgeable and fully capable of handling the assignment.

Conceptual Cost of Proposed Plant

It is requested that a conceptual total cost of the plant proposed be included with your proposal.

FORM OF PROPOSAL

Quoted Prices

It was requested of the bidders in this solicitation that a fixed price for a defined scope of services be provided as alternate pricing which provided a base price and a description of the method to be employed for price adjustment. The alternate pricing proposal shall also include a defined scope of services offered.

The alternate pricing methods described by some bidders are considered to be satisfactory for evaluation purposes. It is the preference of Florida Power Corporation with alternate pricing quotations that total fee for services offered be included in the base price, instead of being assigned as a percentage of recoverable cost.

Replication/Duplication

Where reference to replication or duplication appears in this bid solicitation, it is not the intent of Florida Power Corporation to either replicate or duplicate another plant design in the full meaning of the word.

It is the intent of Florida Power Corporation that the A/E for bidding purposes, select and identify a plant which generally meets the technical parameters of the CR 4 coal-fired unit, with an output capability of 600 MW or somewhat less, as a base for their proposal.

The proposal shall consider and provide for modification of the base plant design, to accommodate equipment differences and characteristics which will result from equipment purchases made by Florida Power Corporation. All equipment purchases will be made through the competitive bidding process. It is desired by Florida Power Corporation that the A/E apply prior developments and available knowledge to the best advantage in the design of this plant to provide a high quality plant design at the lowest possible cost.

We have enclosed a CR 4 Design, Division of Responsibility which delineates the assignment of design responsibility for bidding purposes.

Modeling

Florida Power Corporation's requirements for modeling would be limited to the turbine front end piping.

Some bidders described other areas where in their judgment modeling may be beneficially utilized. In these instances, it is requested the bidders include in their proposal a description of the design areas for which they plan to make models and a narrative description of the benefits that would be provided by modeling. It will be satisfactory to quote separate prices for modeling.

Scheduling Methods

It is the desire of Florida Power Corporation to have the project schedule including the schedule for startup, testing, construction, procurement and design developed by the A/E and maintained with input from the Owner as required. The A/E shall maintain the schedule through the design phase and until the start of construction, at which time the maintenance of the project schedule will be assumed by the Owner.

Dependent on the scheduling methods employed by the A/E, it may be required that some sublevel scheduling be conducted to meet the described requirements.

Discussions of the interface of Florida Power Corporation's GPIS with the A/E's scheduling and cost estimating system developed that the system utilized by most A/E's is largely compatible with the GPIS. It is Florida Power Corporation's preference that the A/E submit a description of the scheduling system they plan to use and examples of the schedule reports they will supply. It is the intent of Florida Power Corporation to utilize the A/E's existing scheduling system to the highest degree possible, and requests only those changes which will make it possible to assume the maintenance of the schedule with a modified GPIS at a later date.

Florida Power Corporation will provide guidelines for coding of activities and established interfacing activities between project schedule components such as engineering, procurement, fabrication, licensing and construction. Each component may have the capability of being run independently or collectively.

Cost Reporting

With regard to cost reporting: Florida Power Corporation will require: (1) cost estimates by purchases and contracts as well as original cash requirements forecast consistent with the various schedules prepared by the A/E; and (2) a cost breakdown by Federal Power Commission accounts as well as the Florida Power Corporation Construction Chart of Accounts. The A/E will handle all cash requirements estimating until such time as the scheduling responsibility is transferred to Florida Power Corporation.

It is requested the A/E supply with their proposal a typical example of project estimate.

Standard Procedures

It is the intent of the reference to standard procedures in the form of proposal, to secure from the A/E a listing of typical procedures which are normally implemented for control of their projects and one or two examples of these typical procedures.

Standard Specifications

It is the intent of this reference in the Form of Proposal to solicit from the A/E several examples of specifications which are normally used on projects.

Standard Drawings

The form of proposal requests the A/E supply a list of standard drawings. This reference is intended to mean a listing of typical drawings such as electrical one-line diagrams, flow diagrams, general arrangement drawings, etc., which are normally developed for a coal unit.

System Description

The reference to system description in the form of proposal is intended to secure from the A/E an example of a typical system description which describes the design criteria, and operation of the system and the equipment which the system contains.

AGREEMENT

The following listed items pertain to the "draft" Agreement intent:

Contractor's Services, Engineering

We have developed a Division of Responsibility matrix which identifies the design activities and services and assigns responsibility for them to either Florida Power Corporation or the A/E. It is the intent of this document to further clarify the A/E scope of activity for bidding purposes.

Procurement Interface

For procurement, the A/E will supply the specification for soliciting bids, and will perform technical evaluations as requested, and will revise the specification after award and maintain the specifications for the duration of construction. Florida Power Corporation will supply the terms and conditions for the invitation to bid. They will also perform commercial evaluations, issue purchase orders and contracts, and administer these activities, including expediting and inspection as required.

Florida Power Corporation will expedite supplier design information and drawings. Purchase orders and contracts will provide for direct contact between contractors and suppliers for resolution of technical matters. Any technical changes which result in a change of the value of purchase orders or contracts must have prior approval by Florida Power Corporation and will be covered by purchase order or contract revisions.

Specifications

Specification format and content will be mutually agreed between Florida Power Corporation and the A/E. Spare parts requirements are to be included in specifications.

Preoperational Test Procedures

Preoperational test procedures will be developed by Florida Power Corporation.

Quality Assurance

It is expected the A/E will have a quality program for controlling the quality of their own performances.

Quality requirements for purchased equipment and services shall be included in the specifications.

Florida Power Corporation will perform all contractor and supplier quality assurance coverage as required.

Project Procedures Manual

Florida Power Corporation requires that one project procedures manual be developed for the project by the A/E including the Florida Power Corporation project activities. Florida Power Corporation will provide input as required covering their activities for development of the manual.

Performance Incentives

Florida Power Corporation is interested in performance incentives for the project design activities and requests that the bidders supply a description of an incentive program they consider appropriate for this application.

Commitments for Equipment and Services

Florida Power Corporation plans to make no commitment prior to January 1, 1978, for materials, equipment or services, other than A/E services and services for licensing and site exploration as required. It is requested that the A/E's supply the following information with their quote:

(a) With first commitment by FPC to suppliers January 1, 1978, what do you estimate will be the percentage of design completion in October 1978 at start of construction?

(b) On what date (latest) is suppliers design information required to have approximately 75% of design completed by October 1978 start of construction?

Site Liaison Engineering

Site liaison engineers supplied by the A/E's are expected to be knowledgeable, experienced people capable of interpreting designs and making on-the-job design decisions. It is expected the assigned people will be assigned responsibility for making design decisions to avoid the construction delays usually resulting from having to communicate design questions back to the design office for resolution. It is expected that an engineer will be required at the jobsite for only the period of activity of any given discipline, and for some period of time during startup and test.

Design Criteria - General Information

Plant shutdown facilities to provide for cold starts including steam line drains. For hot starts, a bypass system will be required. Ash pond is to be designed by A/E; a pump house and a recirculation system will be required.

CR 4 is intended to be a self-supporting plant and will require facilities for administrative offices and plant services.

Some freeze protection may be required, but this is minimal.

Fiberglass circulating water pipe will be considered for this unit.

Plant design planning shall be on the basis of two (2) units on a slide-along design. Control cable design for the second unit when designed would be uniquie for the unit. The following indicates those facilities that shall be sized for two (2) units:

Control Room
Ash Storage
Coal Handling
Cooling Tower Makeup & Blowdown System
Water Treatment
Personnel Facilities
Common Plant Services
(Service Air, Control Air, Light Oil, Potable Water, etc.)

Plant design criteria is to be developed at the start of design. Systems major and general requirements, including sizes, pressures, materials, and other parameters to be mutually developed. ASME codes and standards are to be used for design.

Cooling tower will be natural draft or mechanical draft, fresh water for bid purposes. It is anticipated that some studies in this respect will be required of the A/E. Cooling tower blowdown is also to be determined and will require study and recommendations by the A/E. Florida Power Corporation will provide makeup water supply to the site.

Turbine driven feed pumps shall be included. The feed pumps shall be on the operating floor unless such location interferes with turbine installation and access.

Coal bunkers shall be the silo type.

Precipitators to be of a side-by-side design to facilitate ash handling.

Coal unloading, rail and barge facilities now existing at Crystal River and servicing Units 1 and 2 are capable of supplying the new unit(s) and will not be supplemented. Coal blending facilities and conveyors over the existing intake and discharge canals shall be provided. The clearance height over the canals will be supplied by FPC at a later date.

Ash handling facilities shall include an ash pond and a silo for dry flyash storage.

Coal selection for design purposes will be supplied to A/E on or about May 1, 1977. For quoting purposes, the coal will be predominately Eastern coal with some blending of Western coal. Coal will be sized and washed at the mine and blending will be handled at the power plant. Recrushing will be performed at the power plant prior to pulverizing.

Sincerely,

JVMaloney

John V. Maloney
Purchasing Manager

JVM/bdc

CRYSTAL RIVER 4 DESIGN

DIVISION OF RESPONSIBILITY

ACTIVITY	A/E	FPC
SITE:		
License Preparation:		X
(Input as Requested by FPC	X	
PLANT LOCATION:		
Sub-Structure Exploration Specification	X	
Core Boring & Supply Results to A/E		X
LAYOUT	X	
SURVEY		X
FRESH WATER TO SITE		X
ROADWAY		X
RAIL SIDING		X
OTHER FACILITIES:		
Transmission		X
Sewage Disposal		X
Fencing, Site Paving	X	
Construction Building		X
Construction Personnel Facilities		X
PERMANENT WAREHOUSE	X	
ADMINISTRATION BUILDING	X	
COOLING WATER MAKEUP AND BLOWDOWN SYSTEMS	X	
ASH POND	X	
ASH DISPOSAL SILOS	X	
COAL HANDLING FROM UNLOADER	X	

CRYSTAL RIVER 4 DESIGN

DIVISION OF RESPONSIBILITY

ACTIVITY	A/E	FPC
PLANT:		
Total Power Block Design	X	
Precipitator & Chimney	X	
Water Treatment	X	
Piping (Over 2" Dia.)	X	
Piping (2: Dia. & Under)		X
OTHER SERVICES:		
Project Schedule	X	
Project Estimate	X	
Procurement		X
Inspection		X
Expediting		X
Bid Evaluation		
Technical (As Assigned after Screening)	X	
Commercial		X

RESPONSES

TO

BLACK & VEATCH LETTER OF March 23, 1977

1. We feel a better definition of the scope of the coal handling facilities is needed. We assume a portion of the system will be designed by the Engineer and a portion will be designed by others under contract to your fuels subsidiary. The interface points need to be defined.

   You also mention beneficiation facilities. We need further definition of this. Are you considering an on-site wash plant or simply considering the necessary coal crushing and blending facilities?

   The existing barge unloader and proposed rail unloading systems for Units 1 & 2 will be used for unloading. All additional conveyors, stacker-reclaimers, crushers, scales, etc., will be designed by the A/E.

   We do not have a coal yet, but plan to have a range of coal parameters by May 1, 1977; therefore, we cannot advise you precisely what beneficiation facilities are required. For proposal purposes, consider only the necessary blending and crushing facilities.

2. The interface between FPC and the Engineer for purchasing activities should be defined.

   a. Will FPC require conformed specifications and contracts after the purchase is completed?

      FPC will perform the purchasing and will require conformed bilateral purchase orders and contracts after the purchase is completed.

   b. If we must evaluate unpriced proposals, will we be required to evaluate all proposals or will FPC do a preliminary screening and eliminate those bidders obviously not in contention from a price standpoint?

      FPC will perform a preliminary screening of proposals from bidders and will notify the A/E of those technical proposals to be evaluated.

3. The interface between FPC and the Engineer on scheduling and cost reporting activities should be defined?

a. Will FPC, through use of its GPIS system, handle overall project scheduling? We would anticipate running our management control schedule and detailed engineering schedules for internal project control and providing input to the FPC GPIS system. Is our assumption correct?

Yes, Florida Power will provide guidelines for coding of activities and established interfacing activities between project schedule components such as engineering (design, specs., drawings, studies), procurement, fabrication, licensing and construction. Each component may have the capability of being run independently or collectively.

b. On cost reporting, we assume you will need cost estimates by purchases and contracts and, in addition, a breakdown by FPC accounts. We further assume that you will monitor actual cost performance against the estimates and will handle all cash flow estimating and cash flow reporting. Are our assumptions correct?

With regard to cost reporting for the project, Florida Power Corporation will require: (1) cost estimates by purchases and contracts as well as original cash requirements forecast consistent with the various schedules prepared by the A/E; and (2) a cost breakdown by Federal Power Commission accounts as well as the Florida Power Corporation Construction Chart of Accounts. The A/E will handle all cash requirement estimating until such time as the scheduling responsibility is transferred to Florida Power Corporation. It is our intention that Florida Power Corporation handle cost reporting for the project.

4. We would plan to have design packages 100 percent complete prior to construction as you require, assuming FPC decision making and purchasing is accomplished in a timely manner to enable us to do this.

You have also required 75 percent overall completion of engineering by October 1, 1978. We don't believe this is necessary since the work would be done in packages and there could be as much as two years' time lapse between the first construction package and the last construction package. Further, we feel that it will not be possible for you to make decisions and complete purchases rapidly enough to permit engineering to be 75 percent complete by October 1, 1978. We would submit a bar chart schedule with our proposal showing the approximate schedule for engineering and the interface with construction packages so that engineering could be 100 percent complete on a given construction package prior to award of that contract.

We required 75 percent completion of design before start of construction based on the assumption that this plant, to a large extent, would be an adaptation of an existing design suitable for FPC's selection of major equipment. Our objective is to have as much design completed as possible before the start of construction.

5. With regard to your proposed contract Article II, Item E, we would like to have you further define the amount of site liaison engineering you require since this is to be included in the fixed price. On our previous assignments for FPC, you have not found it necessary to have us furnish resident engineers in order to interpret our plans and specifications.

   It is the intent of Article 11, E, that Site Liaison Engineers are required and would include one per principal discipline, i.e., civil and/or civil/structural, mechanical, electrical and instrumentation/control in residence on site during each respective phase of the work.

6. With regard to your proposed contract Article IV, A, should Item 1, Procedures Manual, also be included as a part of the fixed price? We feel it should be.

   The Project Procedures Manual should be included in the scope of fixed price work. All project related interfaces within the A/E and the FPC organization are to be included.

7. With regard to your proposed contract Article V, A, we would like to suggest that progress payments be based on a schedule developed from estimated manpower assignments over the duration of the project rather than equal monthly payments for a mutually agreed period. We would like to discuss this with you.

   We will be happy to discuss the payment scheme for the A/E contract, however, Florida Power Corporation strategy should consider:

   a. The cost of money implicit in any agreement.

   b. Inclusion of as much work as can be properly defined and managed in the fixed price scope.

   c. No significant "prepayment" for A/E services over the life of the contract.

   d. Some incentive to perform according to the provision of the contract or a penalty for non-performance.

8. Proposed contract Article V, B, would need to be adjusted to reflect our standard accounting month which runs from the 27th to the 26th. Would this be acceptable?

   Florida Power Corporation has no compelling reason to reject this proposal so long as the establishment of a stable billing/payment cycle is not impaired and budgetary controls are not compromised.

9. We would like further definition of your requirements for information under Items 16 through 20 of your FORM OF PROPOSAL.

   (16) What are your project control methods?

   (16) This question is intended to provide for you the opportunity to present the methods used in your activities to control design, schedule costs, etc., and to provide examples of these control tools as you may elect.

9. We would like further definition of your requirements for information under Items 16 through 20 of your FORM OF PROPOSAL.

(16) What are your project control methods?

(16) This question is intended to provide for you the opportunity to present the methods used in your activities to control design, schedule costs, etc., and to provide examples of these control tools as you may elect.

(17) What standard procedures do you have available for application to this project?

(17) We are providing in this item an opportunity for the bidders to present a listing of standard project procedures which are normally implemented on their projects. Your response to this question may be a listing of procedures and examples from a past or present project, or a narrative description of procedures, whichever you may elect to provide.

(18) Supply a listing of the standard specifications you would utilize for this project. Provide several typical examples.

(18) This item is intended to secure from bidders a listing of specifications which are normally developed for a coal unit.

(19) Supply a listing of the standard drawings you plan to utilize for this project.

(19) The standard drawings referenced in this item may be included but not limited to:

(a) Typical electrical one-line diagrams
(b) Typical flow diagrams
(c) General arrangement drawings

This item is intended to secure from bidders a listing of drawings which are normally developed for a coal unit.

(20) Systems Description

(20) This item requires that system descriptions be prepared for all systems and major equipment. These descriptions are to contain the operation and design of the systems in sufficient detail so that operating personnel can become familiar with the equipment and systems and to be used in the development of operating and maintenance procedures.

70240-12100 Crystal River Unit #4
CR[illegible]-00002 BLACK & VEATCH
Engineering Services

CR4-00002 CCONTRACT

BLACK & VEATCH
Engineering Services

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CONTRACT/AGREEMENT

FOR

ENGINEERING SERVICES

BETWEEN

FLORIDA POWER CORPORATION

AS OWNER

AND

BLACK & VEATCH

CONTRACTOR

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AGREEMENT
FOR
ENGINEERING SERVICES
FOR
CRYSTAL RIVER #4 (2 UNITS)

This AGREEMENT, made this _____ day of _________________ effective the _____ day of _____________ by and between FLORIDA POWER CORPORATION, a corporation organized and existing under the laws of the State of Florida, with its principal office at 3201 Thirty-Fourth Street, South, St. Petersburg, Florida, hereinafter referred to as the "Owner", and ___________________________, a corporation organized and existing under the laws of the ________________________________, with its principal office at ________________________________, hereinafter referred to as the "Contractor".

ARTICLE I THE PROJECT

The Project consists of a new steam-electric generating plant at an existing site at Red Level, Florida, which, for the purpose of the AGREEMENT, SHALL BE REFERRED TO AS Crystal River #4 with provision for a future unit. The unit shall consist of an approximate 600 MW turbo-generator unit and a coal-fired steam generating unit supplying steam at 2,400 psig, 1,000 F/ 1,000 F reheat, together with necessary auxiliaries and accessory equipment, and with such facilities as shall be required for the installation at this plant site including, but not limited to, intake and discharge facilities, coal handling, unloading and storage facilities, access roads, railroad spur track, office and machine shop facilities, and such other facilities as may be described in the Crystal River #4, "Project Description", Appendix A.

The Project will be further described in a Technical Scope Document and a Scope of Services Document to be developed by Contractor under this Contract. These documents shall be submitted for Owner's review and approval.

ARTICLE II CONTRACTOR'S SERVICES, ENGINEERING

Contractor shall perform or be responsible for the performance of the services generally described in this Article entitled, "Contractors Services".

A. Project Management

Contractor shall be responsible for coordinating all phases relating to the Project, including, but not limited to:

1. Assisting Owner in development of objectives and the basic work plan.

2. Administration of this Agreement.

3. Coordination of planning, scheduling, and cost control program.

4. Monitoring performance and recommending to Owner appropriate corrective action as required.

5. Periodic reviews of status.

B. <u>Engineering</u>

Contractor shall perform engineering work, including but not limited to, preparation of civil, structural, mechanical, electrical, and instrumentation designs, specifications, drawings, system descriptions, "as-built" drawings on a current basis, and estimates of material quantities as required to properly describe and detail the Project, including design criteria for interface of the Project with existing facilities.

Contractor shall be responsible for the design of the Project in accordance with the requirements of applicable codes and standards, with the exception of design aspects of manufactured components which do not affect interface compatibility and of those systems which are designed by the turbine generator supplier.

Certain drawings, specifications, and other design documents shall be submitted to the Owner for review and comment as described in the Project Procedures Manual. Such Owner action shall not relieve Contractor of its responsibility as engineer for the Owner.

Contractor may relay on written information furnished by vendors with respect to manufactured components and those systems designed by the turbine generator supplier.

Contractor shall advise and consult with Owner in the formulation of criteria for the Project regarding the choice of components. Contractor shall secure directly from the turbine generator supplier and all other suppliers the information required from them for Contractor to perform its services hereunder.

Owner shall obtain in its contracts and purchase orders the right of Contractor to communicate directly with the suppliers. Contractor shall furnish these suppliers any plant design information that they may require and which is within Contractor's scope of responsibility.

Contractor shall comply with Florida State Law regarding the practice of professional services, including certifications of Project drawings and engineering documents.

C. Start-Up and Testing Services

The start-up of components, calibration of controls and equipment, operation of the Project or any portion thereof, functional verification tests, and other start-up and operation functions of the Project shall be under the sole responsibility and control of Owner and shall be performed by Owner's personnel.

Contractor will, during the design phase, provide for the operability and testability of Contractor-designed systems. In addition, Contractor will furnish preoperational testing personnel from Contractor's established offices to assist Owner's operating organization in preoperational testing of the completed Project or portions thereof during a trial or preliminary period. The performance of services by such personnel shall be under the supervision, direction, and control of Owner, and the services performed by such personnel will include the following:

1. Assistance with planning, coordinating, and witnessing systems and equipment initial operation, flushing and preoperational tests.

2. Providing consultation to Owner on systems operational features.

3. Consulting with and advising Owner's Engineering staff and the suppliers regarding necessary modifications, if any, to equipment.

4. Collaborating with and assisting Owner's engineering and project staff in setting up initial preoperational testing, start-up, operating and maintenance schedules, procedures and practices.

D. Licensing and Permits

Contractor shall provide assistance as directed by Owner in obtaining all necessary federal, state and local licenses and permits required for the Project. Such assistance may include, but is not necessarily limited to, the research for, preparation, assembly and printing of license and permit applications, drawings and reports, as well as the presence for the testimony of Contractor personnel, who have been assigned to the Project, at hearings pertaining thereto. Owner and Contractor shall have responsibility for the preparation of specific license and permit applications.

E. Site Liaison Engineering

Contractor will assign experienced and qualified engineers to the site to interpret its design drawings, specifications, and the construction work plan. The assigned engineers shall have authority to recommend and resolve design changes with Florida Power Corporation Engineering as required and thereby not hinder construction progress.

F. Subcontractors and Outside Associates and Consultants

Any subcontractors and outside associates or consultants required by the Contractor in connection with the scope of services will be limited to such individuals or firms as specifically approved by the Owner. Any substitution in such subcontractors, associates, or consultants will be subject to the prior approval of the Owner.

G. Contractors, Other Services

Contractor shall provide other services as required in support of engineering and the Project as follows:

1. Review of site layout, including buildings and other facilities.

2. Review of specifications and drawings for suggested coordination and proper interface of construction.

3. Review of specifications for proposed contract packages.

4. Review or appraisal of prime or general site contractors procedures as requested by the Owner.

5. Provide additional associated services as directed by the Owner at agreed upon rates.

H. Project Control

Contractor shall develop and implement a program of controls for the Project as follows:

1. The Contractor will be responsible for the preparation of preliminary engineering, procurement, and construction schedules which shall be submitted for Owner's review and release for use.

   The engineering schedule shall be coordinated with the procurement and construction schedules to avoid construction delays, and when mutually agreed, shall be the controlling document for time of performance of engineering.

2. Contractor shall prepare, maintain, and periodically present to Owner detailed plans, schedules and reports as required by Owner defining the time and manner within which engineering and other assigned responsibilities will be accomplished.

I. Procedures Manual

Contractor shall prepare a Project Procedures Manual covering all elements of scope of services which shall serve as an administrative guide and shall outline organizational responsibilities, lines of communication, procedures, accounting and financial procedures, and the timing and content of cost, progress and other reports. The Procedures Manual will be subject to review and comment by the Owner. As part of the Procedures Manual, Contractor will develop with Owner a division of responsibility setting forth the responsibilities and detailed scope of work of Owner, Contractor(s) responsible for engineering and construction, the site architect-engineer, and the supplier of the turbine/generator and suppliers of other major equipment and materials.

The Project Procedures Manual may be amended by mutual agreement.

To the extent any of the provisions of the Project Procedures Manual may conflict with this Agreement, this Agreement shall govern.

ARTICLE III <u>INFORMATION AND ITEMS TO BE FURNISHED BY OWNER</u>

Owner will develop with the Contractor all criteria and full information as to its requirements for the project, including but not limited to preferred location of plants, building orientation, existing facilities and interface requirements.

Owner will provide to the Contractor all available written data pertinent to the site of the project, including reports and any other data affecting the design and/or construction of the Project.

Owner will obtain at its expense and furnish to the Contractor all data as required by the Contractor on property, boundary, right-of-way, topographic and utility surveys, soils reports, including core borings, probings, and other sub-surface explorations, information and laboratory tests; all of which the Contractor may rely on for its preparation of the design drawings and specifications for this Project.

Owner will secure at its expense, all leases, titles, concessions, bonds, deposits, permits, licenses, easements, rights-of-way necessary for the engineering, construction and operation of the Project, except for licenses to permit the Contractor to do business in the jurisdiction where the Contractor's services are to be performed.

Owner will guarantee access to the property and make all provisions for the Contractor to enter upon public and private lands as required for the Contractor to perform its services under this Agreement.

Owner will obtain in its purchase orders and contracts the right of the Contractor to communicate directly with suppliers and have access to the facilities of the suppliers.

Owner will examine all studies, reports, sketches, schedules, budgets and cost information, specifications, drawings, and other documents presented by the Contractor to the Owner and will render in writing their decision pertaining thereto within a period mutually agreed upon.

Owner will give prompt written notice to the Contractor whenever the Owner observes or otherwise becomes aware of any unsatisfactory conditions pertinent to the Project.

Owner will notify and authorize the Contractor to provide at the Owner's expense necessary Associated Services at agreed upon rates.

ARTICLE IV COMPENSATION

For the performance of its services, the Owner shall pay the Contractor in the manner and at the times herein specified.

A. Fixed Price Work

The Owner shall pay the Contractor the fixed price of $____________ for Engineering Services described under Article II Contractor Services, A. Project Management as applicable, B. Engineering, E. Site Liaison Engineering, G. Contractors Other Services, H. Project Control as applicable, and as described in the Scope of Services and Technical Scope documents to be developed for Owner's approval.

Fixed price work will be billed and paid on a mutually agreed basis to be determined.

B. Associated Services - Recoverable Costs

Owner shall reimburse the Contractor for all costs and expenses reasonably incurred by the Contractor and authorized by the Owner for the performance of Associated Services not included under the Fixed Price scope of work.

1. Direct Payroll and Related Personnel Costs

Costs and related expenses incurred by Contractor in accordance with its established personnel policies, including all salaries and wages of personnel while engaged directly in the performance of the Services, plus Contractor's standard payroll additives to cover all employee benefits and allowances for vacation, sick leave, holiday, and company portion of employee insurance and retirement benefits, all payroll taxes, premiums for public liability and property damage liability insurance, Workmen's Compensation and all other insurance premiums measured by payroll costs, and other contributions and benefits imposed by any applicable law or regulation.

The rate of Contractor's standard payroll additives shall be verified annually by independent or Owner's audit, and shall be subject to adjustment at the start of each calendar year, in accordance with any revised legal requirements, insurance rates, or changes in Contractor's personnel policies.

2. Indirect Costs

An amount equal to ______ percent of the direct costs described in Paragraph 1 above, excluding premium portion of overtime work, to cover the indirect costs to Contractor of maintaining and operating established offices, which indirect costs are not in fixed prices and shall not duplicate any other costs.

3. Other Direct Costs

Other costs incurred in the performance of the Services including such costs as:

a. Travel, subsistence, and relocation and return of personnel engaged in the performance of the Services, other than personnel permanently assigned.

b. The cost of all materials and supplies (other than engineering supplies) used in the performance of the Services.

c. Costs for reproduction of plans, specifications, reports, and other data at Contractor's standard rates.

d. Computer usage, including related operator time and use of Contractor's standard programs, at the standard rates established by Contractor.

e. All long distance communication expenses, not otherwise reimbursable hereunder, at cost to Contractor.

f. All costs associated with consultants, subcontracts, and other outside services and facilities to the extent the same are approved by the Owner and are utilized directly in the performance of the Services.

g. The costs of establishing and operating temporary facilities required to perform and support the Services, including but not limited to temporary structures, local transportation and communication and other facilities required for the welfare of field personnel.

The rate items (b), (c), (d), and (e) are subject to change each calendar year in accordance with changes in costs. Major or unique costs and expenses for items (f) and (g) are subject to prior written approval by Owner. The Project Procedures Manual will define "major" and "unique" costs and expenses.

ARTICLE V MANNER AND TIME OF PAYMENT

A. Payment of Fixed Price(s) for Engineering Services shall be in _______ equal payments beginning ______________ and ending __________________ (as mutually agreed between Owner and Contractor).

B. Payment of Recoverable Costs

1. For the purposes of this Agreement, the Contractor's monthly closing of accounts for billing purposes shall be as of the last day of each calendar month, except that payroll and related personnel costs shall be as of the Friday preceding the last full work week of each calendar month. As soon as practicable after the end of each month, Contractor shall submit to Owner a complete statement of the Recoverable Costs incurred during the preceding month, prepared in such forms and supported by such invoices, payroll records, and other documents as Owner shall require.

2. Following Final Acceptance of Contractor's services hereunder, Contractor shall submit to Owner a statement showing Final Recoverable Costs.

ARTICLE VI ACCOUNTING OF COSTS

Contractor shall maintain books and accounts of the Recoverable Costs in accordance with generally accepted accounting principles and practices. Contractor shall also keep such books and accounts on a current basis in accordance with the Federal Power Commission Classification of Accounts. For the period of this Agreement until three (3) year(s) after final Acceptance of the Services, Owner shall have the right to audit such books and accounts of Contractor during normal business hours to the extent required to verify the direct costs incurred hereunder.

ARTICLE VII CHANGES AND EXTRA WORK

A. Changes to Scope of Services

Owner may require or approve changes in the Project. Modifications or additions to the Project required by regulatory agencies shall also be considered changes within the meaning of this Article. When such changes result in increased or decreased costs, there shall be an adjustment in fixed price in accordance with a change procedure to be included in the Project Procedures Manual which will provide for:

1. No change in price for changes of a nominal value.

2. Contractor supplying to the Owner a written description of the change, the cost and schedule impact of performing the change.

3. The Owner will review and comment or approve the change.

4. Contractor will perform the change as scheduled and the price will be adjusted as mutually agreed.

B. Extra Work

In the event Owner desires Contractor to perform extra work not within the general interpretation of the Contractor's scope of services, such extra work shall be performed if accepted by Contractor which acceptance will not be unreasonably withheld, for such amounts and on such basis as the parties in each case shall be agreed upon prior to the performance of such extra work.

C. Time Extension

The parties hereto shall also agree upon an equitable extension of the time of performance and approved engineering schedule revision, if applicable, on account of any changes or extra work pursuant to this Article.

D. Disputes

In case of any dispute between the parties hereto concerning whether extra work is being performed, or the price to be paid therefore, Owner shall determine whether such work shall be continued, and the parties shall agree upon the price, but in no case shall work be halted pending such agreement without Owner's consent.

ARTICLE VIII TIME OF PERFORMANCE

Contractor shall use their best efforts in performing the services hereunder and shall be responsible to control its activities in accordance with the approved engineering schedule to permit scheduled commercial operation date of October 1982 for the unit.

ARTICLE IX METHOD AND MANNER OF PERFORMANCE

Contractor shall be an independent contractor in the performance of the services and shall have complete charge and control of the personnel engaged in the performance of the services. Contractor shall be entitled to rely upon information furnished by Owner.

ARTICLE X WARRANTIES AND REMEDIES

A. Contractor will perform its engineering services with that degree of skill and judgment which is normally exercised by recognized professional engineering firms with respect to services of a similar nature, including compliance with applicable federal, state, and local laws, ordinances and regulations; provided, however, that Owner shall be solely responsible for determining the economic feasibility of compliance with a statutory or regulatory design requirement where such requirement is conditioned upon such economic feasibility.

B. Contractor will re-perform at its expense such of its engineering design services as are deficient as a result of Contractor's failure to perform said services in accordance with these standards. The Contractor will be responsible for all costs incidental to such redesign including, but not limited to, the repair, replacement and testing of installed equipment and for the removal, replacement reinstallation and re-testing, as applicable, of equipment and materials necessary to gain access to, and any damage to, or changes in the balance of the plant resulting from, required by, or arising out of such redesign, repair, replacement and testing, and these costs collectively shall be borne by the Contractor.

C. Contractor warrants such redesigned work against defective design for the warranty period, or for a period of eighteen (18) months from and after the date of acceptance of redesign work, whichever is later.

D. Should the Contractor fail to promptly, on notification from the Owner of design deficiencies, make the necessary redesign and accept responsibility for the costs incidental to such redesign as described in this Article, the Owner may perform or cause to be performed the same at the Contractor's expense.

E. Contractor and its surety or sureties shall be liable for the satisfaction and full performance of the warranties set forth herein.

F. The Warranty Period commences with the effective date of this contract and terminates one year from and after Commercial Operation Date of the electric generating unit.

G. If Contractor personnel are furnished to perform services in connection with or incidental to Preoperational Testing or Start-up, Owner shall, in consideration of Contractor's agreement to relinquish direction and control of such personnel to Owner in accordance with Article II C above, release, indemnify and hold harmless Contractor from and against all liability in connection with or incidental to the furnishing of such Preoperational Testing Services or the acts or omissions of Contractor personnel or Preoperational Testing, including but not limited to liability for injury to or death of any person or persons and damage to any property, regardless of where located.

ARTICLE XI INDEMNIFICATION

The Contractor shall assume full responsibility for the foregoing work and labor and will defend the Owner and hold it harmless against and indemnify it for any and all accidents, damages, claims or costs, whatsoever, occasioned wholly or in part by any act or omission of the Contractor; provided, however, the Contractor shall not be obligated to indemnify the Owner for any accidents, damages, claims or costs which are the result of the sole negligence of the Owner. The Contractor's liability under this indemnity, to the extent that it indemnifies the Owner against its own acts or omissions as a joint tort-feasor, shall be limited as follows: General and Automobile Liability, Bodily Injury limits $500,000 each person and $1,000,000 each occurrence; General and Automobile Liability Property Damage limits $100,000 each occurrence. If any member of the public, or any employee or agent of the Contractor, or any employee or agent of a subcontractor is injured or killed, or if any property including Owner's or the public's is damaged in the course of work being performed under the provisions of this Contract, Contractor will notify Owner's personnel who is inspecting the work or in his absence Owner's supervisor who originated the Contract. Such notification will be made immediately in person or by telephone and promptly confirmed in writing, and will include all pertinent data such as name of injured party, location of accident, description of accident, nature of injuries, names of witnesses, disposition of injured or deceased person.

ARTICLE XII INSURANCE

The Contractor will carry Workmen's Compensation Insurance as required by statute and will also carry both General and Automobile Public Liability and Property Damage and engineers Professional Liability Insurance acceptable to the Owner, in amounts adequate for the job and commensurate with the liability involved, but, in no event less than General Liability Bodily Injury $500,000 per occurrence and $1,000,000 aggregate; General Liability Property Damage $100,000 per occurrence and $200,000 aggregate; Automobile Bodily Injury $500,000 per person and $1,000,000 per occurrence; and Automobile Property Damage $100,000 per occurrence; and Engineers Professional Liability Insurance in the limit of $20,000,000 for the Project. The Contractor will have the General, Automobile, and Engineers Professional Liability Insurance policies endorsed to provide blanket contractual coverage, expressly with respect to Article XI above, to the full limits of and for the liabilities insured thereunder; and, prior to the commencement of any work hereunder, the Contractor will furnish the Owner with a certificate, in duplicate, on the Owner's Form 90804(S), completed by the Contractor's insurance carrier, showing that the Contractor carries the requisite insurance and that said policies insure the liability assumed by the Contractor under Article XI above.

During construction operations, the Owner shall procure at its own expense a Project Insurance Program for itself, Construction Manager, Architect/ Engineer each Contractor, Subcontractor and Sub-Subcontractor embracing Workmen's Compensation and Employer's Liability, Comprehensive General Liability, and All-Risk Builders Risk.

Contractor's jobsite permanently-assigned personnel are included in this coverage.

Contractor shall furnish Owner with a Certificate of Insurance as evidence that the foregoing insurance is being maintained. Such insurance shall provide for twenty (20) days' written notice to be given Owner prior to cancellation or material modification of the coverage described therein. In the event this insurance or any portion of it becomes commercially unavailable, Owner and Contractor shall cooperate in efforts to obtain such replacement insurance as may be available and this Contract shall be modified accordingly.

ARTICLE XIII DRAWINGS, PLANS, CALCULATIONS, AND SPECIFICATIONS

All drawings, plans, specifications, calculations, and/or models developed by or for the Contractor pursuant to this Agreement shall be the property of Owner and shall be delivered to Owner upon completion of the Services or upon termination as provided in Article XIV below, but Contractor may retain and use copies thereof as herein provided. Contractor may use the product of its engineering effort expended on behalf of Owner for its general reference and the enhancement of its engineering capabilities, but shall not market or sell drawings, plans, specifications, and models developed pursuant to this Agreement without the prior written approval of Owner. Contractor shall review with and supply copies to the Owner of calculations and analyses developed by or for Contractor pursuant to this Agreement as requested by Owner.

ARTICLE XIV NOTICE AND APPROVAL OF RESTRICTED DESIGNS

Contractor shall, to the extent practicable, make maximum use of products, materials, construction methods, and equipment which are commercially and competitively available or which are available through standard or proven production techniques, methods, and processes. Unless approved by the Owner, the Contractor shall not, in the performance of the work called for by this contract, produce a design or specification such as to require in this construction work the use of structures, products, materials, equipment, or processes which are known by the Contractor to be available only from a sole source. As to any such design or specification, the Contractor shall report to the Owner's Authorized Representative giving the reason or reasons why it is considered necessary to so restrict the design or specification.

ARTICLE XV FORCE MAJEURE

Neither party shall be considered in default in the performance of its obligations under this Contract to the extent that performance of any such obligation is prevented or delayed by any cause, existing or future, which is beyond the reasonable control of such party.

ARTICLE XVI TERMINATION

A. Owner may terminate Contractor's Services at any time by giving Contractor thirty (30) days prior written notice of such termination, whereupon Contractor shall:

1. Stop the performance of Contractor's Services hereunder except as may be necessary to carry out such termination as mutually determined between Owner and Contractor; and

2. Take any other action toward termination of Contractor's Services which Owner may reasonably direct.

B. In the event of termination as above provided, Owner shall pay to Contractor the Fixed Price payments to point of cancellation adjusted to represent the actual percentage of design completion and Recoverable Costs incurred prior to termination and in compliance with Paragraph A above, together with costs reasonably incurred by Contractor as a result of termination as mutually agreed between Contractor and Owner.

ARTICLE XVII <u>SUSPENSION OF SERVICES</u>

Owner may suspend, or extend the time for, the performance of Contractor's Services hereunder, in whole or in part, at any time and from time to time upon ten (10) days prior written notice of such suspension or extension. Thereafter Contractor shall resume the full performance of the Services when directed to do so by Owner.

In the event of suspension or extension of the performance of the Services at Owner's request, Contractor shall be entitled to reimbursement for additional costs reasonably and necessarily incurred by Contractor in suspending or extending the Services and during the period of suspension or extension, and in reactivating the Services after the end of the suspension or extension period to the extent that such additional costs are incurred. The schedules for performance of the Services shall be amended to reflect any such suspension or extension.

In the event any suspension of the Services exceeds a reasonable time, not to exceed one hundred eighty (180) days, Contractor may terminate its obligation to perform the Services by so notifying Owner in writing and the provisions of the Article entitled "Termination" shall apply to such termination.

ARTICLE XVIII <u>NOTICES</u>

Any notice provided for or required hereunder shall, except as specified otherwise in this contract, be given to the following:

To Owner:

To Contractor:

or to such other persons or address as either of the parties shall substitute by notice given as herein required.

Such notices shall be given by U.S. Mail, First Class, Postage prepaid, and shall be effective upon receipt unless a later effective date is specified therein.

ARTICLE XIX ASSIGNMENT, SUBCONTRACTS, AND TRANSFER OF RIGHTS

A. This contract shall not be assigned by any party without the prior written approval of the other, but portions of the Services may be subcontracted by Contractor after Owner's approval of award to a particular subcontractor, associates, and consultants.

B. Owner represents that it is the sole Owner of the Project and has sole rights to operate the Project. In the event Owner sells, leases or otherwise transfers ownership, operating rights, or any other interest in the facilities to be constructed hereunder or any part thereof, Owner agrees to require the purchaser, lessee, or transferee to provide Contractor with the identical property insurance and liability protection that Owner is required to provide hereunder and to require such purchaser, lessee, or transferee to release, indemnify, and hold Contractor harmless from and against liability to the same extent Owner has released Contractor from liability or agreed hereunder to indemnify or hold Contractor harmless from and against liability so that neither Contractor's aggregate liability to Owner and such purchaser, lessee, or transferee nor Contractor's liability exposure to third parties will be increased by such sale, lease, or transfer.

ARTICLE XX EQUAL OPPORTUNITY

A. The Contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and of the rules, regulations, and relevant orders of the Secretary of Labor.

B. The Contractor will furnish all information and reports required by Executive Order 11264 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto.

ARTICLE XXI APPLICABLE LAW

This Contract shall be interpreted under and governed by the law of the State of Florida.

ARTICLE XXII SUCCESSORS AND ASSIGNS

This Contract shall inure to the benefit of and be binding upon the successors and permitted assigns of the parties hereto.

ARTICLE XXIII ENTIRE AGREEMENT

Any services provided for herein which were performed or caused to be performed by Contractor prior to the effective date of this Contract shall be deemed to have been performed under this Contract. This Contract constitutes the entire agreement between the parties hereto relating to the subject matter hereof, and supersedes any previous agreement or understandings. Contractural terms and conditions contained in purchase orders, work orders, or other documents issued by Owner to Contractor with respect to the Services shall be of no force and effect and shall be superseded by the terms and conditions contained in this Contract except to the extent agreed to in writing by an officer of Contractor.

IN WITNESS WHEREOF, the parties hereto have entered into this Contract on the day and year first hereinabove written.

OWNER: FLORIDA POWER CORPORATION

WITNESSED BY:

______________________ BY: ______________________

______________________ TITLE: ______________________

CONTRACTOR: ______________________

WITNESSED BY:

______________________ BY: ______________________

______________________ TITLE: ______________________

APPENDIX A
PROJECT DESCRIPTION
CRYSTAL RIVER #4

INTRODUCTION

Florida Power Corporation (Owner) plans to build a new generating facility at the present Crystal River plant site consisting of one unit rated at approximately 600 MW with provision for a future second unit. The unit is to be coal-fired, single reheat steam turbine driven with throttle conditions of 2,400 psig, 1,000/1,000°F. The Crystal River plant site currently has two existing fossil-fired steam generating units and one nuclear generating unit. It is expected that the fuel to be burned will be bituminous coal which will meet the specified environmental requirements for sulfur emissions.

The planned construction start date for the new generating facility is October 1, 1978, and commercial operation is scheduled for October 1, 1982.

This document describes the plant to be constructed and outlines the necessary engineering work to be performed by the Architect-Engineer (Contractor). The applicable environmental regulations of the Florida Department of Environmental Regulation, the Federal Environmental Protection Agency, the U.S. Corps of Engineers, and the Coast Guard must be met in the design of this plant.

Currently the plant site has intake and discharge canals. These canals are to be used for fuel delivery for the new generating facility layout. Utilization of the intake canal and extending the existing coal handling facilities must be accomplished to accommodate the new generating units.

UNIT ORIENTATION

The unit will be oriented on the plant site to take advantage of the existing substations. The units will also be located so that effective use is made of the available land for the cooling water system. The unit orientation must also take into consideration the existing intake canal and fuel handling equipment.

SITE ACCESS

An extension from the existing railroad spur and a new access road from U.S. Highway 19 are to be provided. Good access to the site by rail and highway is desirable to minimize the delivery costs of equipment and material used in construction of the plant.

SUBSTATION

The existing substations at Crystal River Plant will be expanded for the new units. A short transmission corridor will be required from the new units to the existing substation. This corridor will be located on Florida Power property. The substation design will be by the Owner with interfaces by the Contractor.

SCOPE

The Contractor shall provide the engineering and design and associated services for an approximate 600 MW coal-fired steam turbine driven electric generating unit with provision for a duplicate future unit to be located at Red Level, Florida.

GENERAL DESCRIPTION

The unit is to consist of a single boiler supplying steam to a tandem compound single reheat turbine generator unit designed for operation at 2,400 psi steam pressure at the turbine throttle. Main and reheat steam temperature will be 1,000°F. The unit is to be designed to operate at 5 per cent over pressure (2,520 psi) conditions continuously without time limit considerations because of equipment limitations. The unit shall be designed for cyclic operation.

The unit is to be designed to burn coal that will enable the stack discharge to meet Federal, State, and Local air compliance requirements without the use of backend sulfur removal equipment. The design must provide space for the addition of sulfur removal equipment in the future.

An electrostatic precipitator is to be installed for flyash removal.

BOILER

The boilers shall be capable of burning a wide range of coals. The fuel to be burned will be determined later.

ASH HANDLING

The bottom ash handling system shall be a wet system utilizing recirculated fresh water with makeup from wells and/or cooling tower blowdown. The ash storage facility must meet the environmental requirements of the State of Florida and the federal agencies.

FLYASH HANDLING AND STORAGE

The flyash handling system shall be a dry flyash system utilizing silos for offsite disposal of flyash. Facilities to load the flyash into trucks and/or railcars must be provided.

TURBINE GENERATOR

The turbine generator shall be tandem compound, single shaft, single reheat, four flow exhaust, 3,600 rpm with optimized feedwater heating, one stage of which will be a deaerator.

FUEL SYSTEM

The fuel unloading system is to be integrated with the existing system installed for Crystal River Units 1 and 2. The fuel will be unloaded from barges and/or trains and conveyed to the new units. A surge pile will be installed at the new units. All necessary conveyor belts transfer stations, reclaim systems, crushers, trippers, coal silos, coal sampler, and scales shall be included. Coal blending and beneficiation facilities are included.

Coal is to be stored in an area adjacent to the Crystal River 1 and 2 coal storage area. The coal storage area is to contain a 90-day fuel supply at a 75 per cent use factor.

An oil storage tank will be provided for light oil to be used for ignition, warm-up, and flame stability.

CONDENSER COOLING WATER

The unit will be equipped with a cooling tower and closed cycle condenser cooling system. Make up water to the cooling towers will be fresh water obtained from new wells, the Withlacoochee River, and/or the Crystal River. A condenser optimization study will be performed to determine the optimum arrangement of condenser and cooling water system.

CHIMNEYS

The flue gases from each unit will be discharged to a separate concrete chimney. The chimneys will be lined with alloy steels and/or stainless steels capable of withstanding the corrosive atmosphere from the flue gases for the life of the plant.

BUILDINGS AND STRUCTURES

The turbine generator and steam generator will be enclosed. Service building or buildings will be provided containing administrative offices, maintenance shops, chemical laboratory, storerooms, and personnel facilities. Site improvements and facilities will be included as required for a complete installation.

Water treatment equipment will be located in a separate auxiliary building.

WASTE WATER

Waste water from water treating equipment, metal cleaning, sanitary systems, boiler blowdown, coal pile runoff, will be treated and discharged in accordance with State and Federal regulations.

BLACK & VEATCH
CONSULTING ENGINEERS

TEL. (913) 967-2000
TELEX 42-6263

1500 MEADOW LAKE PARKWAY
MAILING ADDRESS: P.O. BOX NO. 8405
KANSAS CITY, MISSOURI 64114

Florida Power Corporation
Solicitation for Proposals
to Perform Engineering and
Associated Services

April 18, 1977
FPC File No. PPC-747

Florida Power Corporation
3201 Thirty Fourth Street South
P. O. Box 14042
St. Petersburg, Florida 33733

Attention: Mr. John V. Maloney
Purchasing Manager

Gentlemen:

This letter proposal relating to fees and charges for the referenced Services, together with our separate document entitled PROPOSAL INFORMATION - ENGINEERING SERVICES FOR CRYSTAL RIVER UNIT 4, are our complete proposal in response to your solicitation letter dated March 10, 1977 and subsequent written and verbal communications.

A. Fixed Price. We hereby propose to provide the Services described in our document entitled PROPOSAL INFORMATION under Section IV, Article 1.0, sub-paragraph (1); and as described further in Article 2.0, for the fixed lump sum price of $7,980,000 to be paid by Florida Power Corporation to the Engineer, payable in accordance with Attachment I, Schedule for Payments, or otherwise as mutually agreeable.

As a separate fixed price to be paid by the Corporation to the Engineer for a model of the piping and structures at the front end of the turbine, if required, the Corporation shall pay the amount of $25,000 on a mutually agreeable schedule.

In all cases, the Categories of Services outlined in Section IV, Article B, sub-paragraph (3) of Corporation's Contract/Agreement for Engineering Services (page 7) are a reimbursible item for which payment is to be made in accordance with Article B of this proposal letter.

B. Payment for Associated Services. The Corporation shall pay the Engineer for the categories of Associated Services described in Section IV, Article 1.0, sub-paragraph (2); and as further described in Article 3.0 of Section IV of PROPOSAL INFORMATION in accordance with the payment provisions of Article C of this proposal letter.

C. Alternate Payment for Services. As an alternate method for payment for all Services, which if selected would supersede Articles A and B of this proposal letter, we propose the following payment provisions.

The Corporation shall pay to the Engineer the sum of the following amounts, payable monthly as the work progresses.

1. The amount calculated as two times the Engineer's payroll cost for time of personnel applied to performance of the Services. Payroll cost equals 1.25 times salary costs.

2. The amount of the out-of-pocket cost of reasonable, identified Other Direct Costs paid by the Engineer and required to carry out the Services. Such Other Direct Costs are described in Corporations' Agreement for Engineering Services form, page 7, sub-paragraph 3.a to 3.g inclusive.

As an exception to Article C, Item 1 of this proposal letter, the multiplier to be applied to payroll cost for the time of Resident Engineers shall be 1.60 instead of 2.0.

D. General Provisions. The following general provisions are a part of this proposal.

1. We have not proposed incentive pricing for Services. We will be glad to discuss reasonable methods you may suggest to eliminate contingencies from pricing.

2. Your proposed resident engineer located in Kansas City is assumed to be liaison and for the account of the Corporation.

3. We respectfully suggest that design engineering would approach completion before each purchase or contract is submitted for bidding; however, completion will likely lag the percentages you generally indicate. This will be due to inability or undesirability to purchase as rapidly as would be required by the indicated completion.

4. The overhead and mulipliers in the proposal are not auditable. Time of personnel and expense are auditable.

5. We have not included documents from other projects. These documents are the property of others. We will be glad to discuss the format and quality of any documents to be provided to the Corporation. Corporation personnel have been informed of our documentation from time to time.

6. Attachment II hereto is your Form of Proposal with information inserted. It is self-explanatory.

We appreciate this opportunity to present this proposal to you. We believe it would result in a quality project on time and on Budget and at as low cost as practicable. We very much want to do it for you.

Very truly yours,

BLACK & VEATCH

Riley D. Woodson
Executive Partner
Head of Power Division

tb
Enclosures

PROPOSED FIXED PRICE PAYMENT SCHEDULE

BILLING PERIOD		PER CENT OF FIXED PRICE
1977	JULY	1.0
	AUGUST	0.7
	SEPTEMBER	0.8
	OCTOBER	1.1
	NOVEMBER	1.1
	DECEMBER	1.4
1978	JANUARY	1.6
	FEBRUARY	2.0
	MARCH	2.2
	APRIL	2.2
	MAY	3.5
	JUNE	3.5
	JULY	3.6
	AUGUST	4.1
	SEPTEMBER	4.1
	OCTOBER	4.1
	NOVEMBER	3.9
	DECEMBER	3.9
1979	JANUARY	3.8
	FEBRUARY	3.4
	MARCH	3.3
	APRIL	3.0
	MAY	3.0
	JUNE	2.8
	JULY	2.7
	AUGUST	2.5
	SEPTEMBER	2.2
	OCTOBER	2.0
	NOVEMBER	1.9
	DECEMBER	1.7
1980	JANUARY	1.7
	FEBRUARY	1.5
	MARCH	1.5

BILLING PERIOD		PER CENT OF FIXED PRICE
1980	APRIL	1.5
(Cont'd)	MAY	1.5
	JUNE	1.4
	JULY	1.1
	AUGUST	1.0
	SEPTEMBER	0.8
	OCTOBER	0.8
	NOVEMBER	0.7
	DECEMBER	0.7
1981	JANUARY	0.6
	FEBRUARY	0.5
	MARCH	0.5
	APRIL	0.4
	MAY	0.4
	JUNE	0.4
	JULY	0.4
	AUGUST	0.4
	SEPTEMBER	0.4
	OCTOBER	0.4
	NOVEMBER	0.4
	DECEMBER	0.3
1982	JANUARY	0.3
	FEBRUARY	0.3
	MARCH	0.3
	APRIL	0.3
	MAY	0.3
	JUNE	0.3
	JULY	0.3
	AUGUST	0.3
	SEPTEMBER	0.3
	OCTOBER	0.3
	NOVEMBER	0.3
	DECEMBER	0.3

ATTACHMENT II
BLACK & VEATCH PROPOSAL LETTER DATED APRIL 18, 1977

FORM OF PROPOSAL
CRYSTAL RIVER 4, UNITS 1 & 2
2 – 600 MW COAL FIRED
GENERATING PLANTS

1. Quoted Fixed Price for performance of Services described under Article IV Compensation, Paragraph A.

   See letter

2. Average Direct Labor Rate at time of quoting

(a)	Home Office Personnel	$ 7.42
(b)	Field Personnel	$10.38

3. Standard additions to cover all employee benefits and allowances for Direct Labor categories, Article IV B.I.

(a)	Home Office Personnel	25 Per Cent of Direct Labor Cost
(b)	Field Personnel	25 Per Cent of Direct Labor Cost

4. Indirect Cost additive to Direct Labor categories described in Article IV B.2

(a)	Home Office Personnel	100 Per Cent
(b)	Field Personnel	60 Per Cent

5. Describe your method for calculating price changes for increases and decreases in "Fixed Price" scope of work.

   For standard engineering work, price changes to the "Fixed Price" scope of work will be calculated by multiplying the estimated man-hours for the change by the current average direct labor rate for the class of labor involved (home office or field personnel) adjusted to include payroll additives (Item 3) and indirect costs (Item 4).

   For specialized consulting work actual salaries of the personnel involved will be used rather than average direct labor rates to calculate "Fixed Price" scope of work changes.

Supply a sample calculation.

Home Office –
200 man-hours x \$7.42 per hour x 1.25 x 2.00 = \$3,710
Field –
1000 man-hours x \$10.38 per hour x 1.25 x 1.60 = \$20,760
Specialized Consulting Work –
300 man-hours x \$8.54 per hour x 1.25 x 2.00 = \$6,405

6. Supply a cost schedule for reproduction of:

Plans	See Proposal Section V, 1.0
Drawings	See Proposal Section V, 1.0
Specifications	See Proposal Section V, 1.0
Reports	See Proposal Section V, 1.0
Schedules	See Proposal Section V, 1.0
Other Data	See Proposal Section V, 1.0

7. Rates for Computer usage

   See Proposal Section V, 1.0

8. Is the proposal based on replication of an existing design, or a near similar design?

   See Proposal Section V, 2.0

9. What approximate percentage of an existing design is planned for replication or duplication?

   As Mutually Agreed

10. If replication of existing design, supply identity of plant.

    See Proposal Section V, 2.0

11. Describe your experience, including the number of similar plants for which you have provided engineering and construction services.

    See Proposal Section V 2.0

12. Will modeling be employed in designing and development of Construction Work Plan?

    See Proposal Section V, 3.0

    If so, to what degree will modeling be employed?

    See Proposal Section V, 3.0

13. Describe methods employed for your engineering planning.

    See Proposal Section IV

14. What are your scheduling methods?

    See Proposal Section IV

15. Please provide a milestone schedule of planned major activities.

    See Proposal Section VII

16. What are your project control methods?

    See Proposal Section V, 4.0

    Please provide typical examples of estimates on other control methods you plan to utilize.

    See Proposal Section V, 4.0

17. What standard procedures do you have available for application to this project?

    Each discipline has a Standard Practices Manual which includes design guides and preferred procedures. This document provides general design guidance for performing the project detail design. Standard drafting room practices are also included in this manual.

18. Supply a listing of the standard specifications you would utilize for this project. Provide several typical examples.

    Each specification for Crystal River 4 will be tailored to the special requirements of Florida Power Corporation. Specification design guides will be used in the development of the specifications.

19. Supply a listing of the standard drawings you plan to utilize for this project. Provide several typical examples.

    See Proposal Section IV, attachment 6

20. Systems Description

    A System Description will be prepared for each system.

21. What are the estimated Engineering and Home Office manhours for this project?

    Home Office – 359,600 manhours
    Field – 15,680 manhours

22. What is your corporate organizational structure?

    Partnership

23. What is your project organizational structure?

    (a) Describe each of the key project team positions and their relationships to management.

        See Proposal Section VI

    (b) Supply resumes of your proposed project team personnel.

        See Proposal Section VI

A G R E E M E N T

FOR

ENGINEERING SERVICES

FOR

CRYSTAL RIVER #4 (2 UNITS)

This AGREEMENT, made and effective this 24th day of June 1977 by and between FLORIDA POWER CORPORATION, a corporation organized and existing under the laws of the State of Florida, with its principal office at 3201 Thirty-Fourth Street, South, St. Petersburg, Florida, hereinafter referred to as the "Owner", and BLACK & VEATCH, a partnership organized and existing under the laws of the State of Missouri, with its principal office at Kansas City, Missouri, hereinafter referred to as the "Contractor".

ARTICLE I THE PROJECT

The Project consists of a new steam-electric generating plant at an existing site at Red Level, Florida, which, for the purpose of the AGREEMENT, shall be referred to as Crystal River #4 with provision for a future unit. The unit shall consist of an approximate 600 Mw turbo-generator unit and a coal-fired steam generating unit supplying steam at 2400 psig, 1000° F/1000° F reheat, together with necessary auxiliaries and accessory equipment, and with such facilities as shall be required for the installation at this plant site including, but not limited to, the cooling tower, intake and discharge facilitie coal handling, unloading and storage facilities, access roads, railroad spur track, office and machine shop facilities, and such other facilities as may be described in the Crystal River #4, "Project Description", Appendix A in Owner Proposal Request.

ARTICLE II CONTRACTOR'S SERVICES, ENGINEERING

Contractor shall perform or be responsible for the performance of the services generally described in this Article entitled, "Contractors Services". The services described in Sections A through I are not necessarily part of the fixed price scope, but are included to provide a description of anticipated services. The fixed price scope of this work is further defined in Article IV-A of this Agreement and further defined and clarified in attached Exhibits A, B and C.

The following documents by this reference are incorporated as a part of this Agreement:

EXHIBIT A - Clarifications and understandings related to the Black & Veatch Fixed Price Proposal dated June 8, 1977.
EXHIBIT B - Black & Veatch Proposal dated April 15, 1977 (including Owner Proposal Request).
EXHIBIT C - Black & Veatch letters dated:
April 18, 1977 with Attachments I & II
April 29, 1977 with Attachment
May 10, 1977 with Attachment
May 12, 1977 with Attachment
June 1, 1977 with Attachment
June 3, 1977 with Attachment

In the event of conflict between any of the above documents or the Agreement, the "Agreement" and the "Clarifications and Understandings" will govern.

A. Project Management

Contractor shall be responsible for coordinating all phases relating to the Project, including, but not limited to:

1. Assisting Owner in development of objectives and the basic work plan.
2. Administration of this Agreement.
3. Coordination of planning, scheduling and cost control program.
4. Monitoring performance and recommending to Owner appropriate corrective action as required.
5. Periodic reviews of status.

B. Engineering

Contractor shall perform engineering work, including but not limited to, preparation of civil, structural, mechanical, electrical and instrumentation designs, specifications, drawings, system descriptions, "as-built" drawings on a current basis, and estimates of material quantities as required to properly describe and detail the Project, including design information in sufficient detail for clearly describing the interface of the Project with existing facilities.

Contractor shall be responsible for the design of the Project in accordance with the requirements of applicable codes and standards, with the exception of design aspects of manufactured components which do not affect interface compatibility.

Certain drawings, specifications, and other design documents shall be submitted to the Owner for review and comment/approval as described in the Project Procedures Manual. Such Owner action shall not relieve Contractor of its responsibility as engineer for the Owner.

Contractor may rely on written information furnished by vendors with respect to manufactured components.

Contractor shall advise and consult with Owner in the formulation of criteria for the Project regarding the choice of components. Contractor shall secure directly from all suppliers the information required from them for Contractor to perform its services hereunder.

Owner shall obtain in its contracts and purchase orders the right of Contractor to communicate directly with the suppliers. Contractor shall furnish these suppliers any plant design information that they may require and which is within Contractor's scope of responsibility.

Contractor shall comply with Florida State Law regarding the practice of professional services, including certifications of Project drawings and engineering documents.

C. Start-Up and Testing Services

The start-up of components, calibration of controls and equipment, operation of the Project or any portion thereof, functional verification tests, and other start-up and operation functions of the Project shall be under the sole responsibility and control of Owner and shall be performed by Owner's personnel.

Contractor will, during the design phase, provide for the operability and testability of Contractor-designed systems. In addition, Contractor will furnish preoperational testing personnel from Contractor's established offices to assist Owner's operating organization in preoperational testing of the completed Project or portions thereof during a trial or preliminary period. The performance of services by such personnel shall be under the supervision, direction and control of Owner, and the services performed by such personnel will include the following:

1. Assistance with planning, coordinating, and witnessing systems and equipment initial operation, flushing and preoperational tests.

2. Providing consultation to Owner on systems operational features.

3. Consulting with and advising Owner's Engineering staff and the suppliers regarding necessary modifications, if any, to equipment.

4. Collaborating with and assisting Owner's engineering and

project staff in setting up initial preoperational testing, start-up, operating and maintenance schedules, procedures and practices.

D. Licensing and Permits

Contractor shall provide assistance as directed by Owner in obtaining all necessary federal, state and local licenses and permits required for the Project. Such assistance may include, but is not necessarily limited to, the research for and preparation of material in support of license and permit applications, drawings and reports, as well as the presence for the testimony of Contractor personnel, who have been assigned to the Project, at hearings pertaining thereto. Owner shall have responsibility for the preparation of specific license and permit applications.

E. Site Liaison Engineering

Contractor will assign experienced and qualified engineers to the site to interpret its design drawings, specifications and the construction work plan. The assigned engineers shall have authority to recommend and resolve design changes with Florida Power Corporation Engineering (subject to prior approval by the Florida Power Corporation Project Manager) as required and thereby not hinder construction progress.

F. Subcontractors and Outside Associates and Consultants

Any subcontractors and outside associates or consultants required by the Contractor in connection with the scope of services will be limited to such individuals or firms as specifically approved by the Owner. Any substitution of such subcontractors, associates, or consultants will be subject to the prior approval of the Owner.

G. Contractors, Other Services

Contractor shall provide other services as required in support of engineering and the Project as follows:

1. Review of site layout, including buildings and other facilities.

2. Review of specifications and drawings for suggested coordination and proper interface of construction.

3. Review of specifications for proposed contract packages.

4. Review or appraisal of prime or general site contractors procedures as requested by the Owner.

5. Provide additional associated services as directed by the Owner at agreed upon rates as defined in Article IV.

Project Control

Contractor shall develop and implement a program of controls for the Project as follows:

1. The Contractor will be responsible for the preparation of preliminary engineering, procurement and construction schedules

which shall be submitted for Owner's review and release for use.

The engineering schedule shall be coordinated with the procurement and construction schedules to permit construction as scheduled, and when mutually agreed, shall be the controlling document for time of performance of engineering.

2. Contractor shall prepare, maintain, and periodically present to Owner detailed plans, schedules and reports as required by Owner defining the time and manner within which engineering and other assigned responsibilities will be accomplished.

I. Procedures Manual

Contractor shall prepare a Project Procedures Manual covering all elements of scope of services which shall serve as an administrative guide and shall outline organizational responsibilities, lines of communication, procedures, accounting and financial procedures, and the timing and content of cost, progress and other reports. The Procedures Manual will be subject to review and comment by the Owner.

As part of the Procedures Manual, Contractor will develop with Owner a division of responsibility setting forth the responsibilities and detailed scope of work of Owner, Contractor(s) responsible for engineering and construction, and the suppliers of other major equipment and materials.

The Project Procedures Manual may be amended by mutual agreement.

To the extent any of the provisions of the Project Procedures Manual may conflict with this Agreement, this Agreement shall govern.

ARTICLE III <u>INFORMATION AND ITEMS TO BE FURNISHED BY OWNER</u>

Owner will develop with the Contractor all criteria and full information as to its requirements for the project, including but not limited to preferred location of plants, building orientation, existing facilities and interface requirements.

Owner will provide to the Contractor all available written data pertinent to the site of the project, including reports and any other data affecting the design and/or construction of the Project.

Owner will obtain at its expense and furnish to the Contractor all data as required by the Contractor on property, boundary, right-of-way, topographic and utility surveys, soils reports, including core borings, probings and other sub-surface explorations, information and laboratory tests; all of which the Contractor may rely on for its preparation of the design drawings and specifications for this Project.

Owner will secure at its expense, all leases, titles, concessions, bonds, deposits, permits, licenses, easements, rights-of way necessary for the engineering, construction and operation of the Project, except for licenses to permit the Contractor to do business in the jurisdiction where the Contractor's services are to be performed.

Owner will guarantee access to the property and make all provisions for the Contractor to enter upon public and private lands as required for the Contractor to perform its services under this Agreement.

Owner will obtain in its purchase orders and contracts the right of the Contractor to communicate directly with suppliers and have access to the facilities of the suppliers.

Owner will examine all studies, reports, sketches, schedules, budgets and cost information, specifications, drawings and other documents presented by the Contractor to the Owner and will render in writing their decision pertaining thereto within a period mutually agreed upon.

Owner will give prompt written notice to the Contractor whenever the Owner observes or otherwise becomes aware of any unsatisfactory conditions pertinent to the Project.

Owner will notify and authorize the Contractor to provide at the Owner's expense necessary Associated Services at agreed upon rates.

ARTICLE IV COMPENSATION

For the performance of its services, the Owner shall pay the Contractor in the manner and at the times herein specified.

A. Fixed Price Work

The Owner shall pay the Contractor the fixed price of $7,994,000.00 for Engineering Services described under Article II Contractor Services, A. Project Management as applicable, B. Engineering, E. Site Liaison Engineering, G. Contractors Other Services, H. Project Control as applicable, I. Project Procedures Manual, and as described in the Scope of Services and Technical Scope documents to be developed for Owner's approval.

B. Associated Services - Recoverable Costs

Owner shall reimburse the Contractor for all costs and expenses reasonably incurred by the Contractor and authorized by the Owner for the performance of Associated Services not included under the fixed Price scope of work.

1. Direct Payroll and Related Personnel Costs

For payroll related charges incurred by the Contractor, the Owner will reimburse the Contractor as follows:

For the first 8,000 manhours:
  Home Office Personnel
    Salary X 1.25 X 1.65
  Field Personnel
    Salary X 1.25 X 1.35
For all manhours above 8,000:
  Home Office Personnel
    Salary X 1.25 X 2
  Field Personnel
    Salary X 1.25 X 1.6

These multipliers will remain constant for the project duration.

2. Other Direct Costs

Other costs incurred in the performance of the Services including such costs as:

a. Travel and subsistence of personnel engaged in the performance of the Services, excluding relocation, return and subsistence expenses for Site Liaison Engineers which is included under the fixed (lump sum) price scope.

b. The cost of any specially printed mylar drawing stock used in the performance of the Services.

c. The cost at standard rates of reproductions of Engineer's drawings and specifications required beyond the following items which are included in the fixed price:

(1) Reproductions for use of Engineer and Company for review and communication.

(2) Fifteen copies of completed specifications ready for issue.

(3) A reasonable number of copies of engineering documents such as project instructions, systems analyses, system design specifications, reports and schedules.

(4) One reproducible copy and one aperture card for all drawings issued for construction and subsequent revisions.

d. Computer usage, including related operator time and use of Contractor's standard programs, at the standard rates established by Contractor.

e. All long distance communication expenses, not otherwise reimbursable hereunder, at cost to Contractor.

f. All costs associated with consultants, subcontractors and other outside services and facilities to the extent the same are required by the Owner.

g. The costs of establishing and operating temporary facilities required to perform and support the Services, including but not limited to temporary structures, local transportation and communication and other facilities required for the welfare of field personnel.

The rate for items (b), (c), (d) and (e) is subject to change each calendar year in accordance with changes in costs. Major or unique costs and expenses for items (f) and (g) are subject to prior written approval by Owner. The Project Procedures Manual will define "major" and "unique" costs and expenses.

ARTICLE V MANNER AND TIME OF PAYMENT

A. Payment of Fixed Price for Engineering Services shall be in accordance with Attachment I to Black & Veatch letter dated April 18, 1977. Should the Contractor fail to maintain the Engineering Schedule, the payments will be adjusted by a percentage equal to the schedule slippage.

B. Payment of Recoverable Costs

1. For the purposes of this Agreement, the Contractor's monthly

closing of accounts for billing purposes shall be as of the 26th day of each calendar month. As soon as practicable after the end of each billing period, Contractor shall submit to Owner a complete statement of the Recoverable Costs incurred during the preceding month, prepared in such forms and supported by such invoices, time, cost and expense records and other documents as Owner shall require.

2. Following Final Acceptance of Contractor's services hereunder, Contractor shall submit to Owner a statement showing Final Recoverable Costs.

ARTICLE VI ACCOUNTING OF COSTS

Contractor shall maintain books and accounts of the Recoverable Costs in accordance with generally accepted accounting principles and practices. Contractor shall also keep such books and accounts on a current basis in accordance with the Federal Power Commission Classification of Accounts. For the period of this Agreement until three (3) year(s) after final Acceptance of the Services, Owner shall have the right to audit such books and accounts of Contractor during normal business hours to the extent required to verify the direct costs incurred hereunder.

ARTICLE VII CHANGES AND EXTRA WORK

A. Changes to Scope of Services

Owner may require or approve changes in the Project. Modifications or additions to the Project required by regulatory agencies shall also be considered changes within the meaning of this Article. When such changes result in increased or decreased costs, there shall be an adjustment in fixed price in accordance with a change procedure to be included in the Project Procedures Manual which will provide for:

1. No change in price for changes within contemplated scope.

2. Contractor supplying to the Owner a written description of the change, the cost and schedule impact of performing the change.

3. The Owner to review and comment or approve the change prior to the performance of the work.

4. Contractor to perform the change as scheduled and the price will be adjusted as mutually agreed.

B. Extra Work

In the event Owner desires Contractor to perform extra work not within the general interpretation of the Contractor's scope of services, such extra work shall be performed if accepted by Contractor which acceptance will not be unreasonably withheld, for such amounts and on such basis as the parties in each case shall be agreed upon prior to the performance of such extra work.

C. Time Extension

The parties hereto shall also agree upon an equitable extension of the time of performance and approved engineering schedule revision, if applicable, on account of any changes or extra work pursuant to this Article.

D. Disputes

In case of any dispute between the parties hereto concerning whether extra work is being performed, or the price to be paid therefore, Owner shall determine whether such work shall be continued, and the parties shall agree upon the price, but in no case shall work be halted pending such agreement without Owner's consent.

ARTICLE VIII TIME OF PERFORMANCE

Contractor shall use their best efforts in performing the services hereunder and shall be responsible to control its activities in accordance with the approved engineering schedule to permit scheduled commercial operation date of October 1982 for the unit.

ARTICLE IX METHOD AND MANNER OF PERFORMANCE

Contractor shall be an independent contractor in the performance of the services and shall have complete charge and control of the personnel engaged in the performance of the services. Contractor shall be entitled to rely upon information furnished by Owner.

ARTICLE X PROFESSIONAL LIABILITY, STANDARDS OF PERFORMANCE & REMEDIES

A. Contractor will perform its engineering services with that degree of skill and judgment which is normally exercised by recognized professional engineering firms with respect to services of a similar nature, including compliance with applicable federal, state and local laws, ordinances and regulations; provided, however, that Owner shall be solely responsible for determining the economic feasibility of compliance with a statutory or regulatory design requirement where such requirement is conditioned upon such economic feasibility.

Contractor will re-perform at its expense such of its engineering design services as are deficient as a result of Contractor's failure to perform said services in accordance with these standards.

B. The Contractor will be liable for all collective costs incidental to such redesign as stated in Article X-A resulting from errors, omissions or negligent acts of the Contractor, including, but not limited to, the repair, replacement and testing of installed equipment and for the removal, replacement, reinstallation and re-testing, as applicable, of equipment and materials necessary to gain access to, and any damage to, or changes in the balance of the plant resulting from, required by, or arising out of such redesign, repair, replacement and testing.

C. Owner shall have right to claims under this Article at any time up to one year after Commercial Operation Date of the electric generating unit.

D. Contractor is responsible for such redesigned work and Owner shall have right to claims under this Article until the expiration of the claim period set forth in Paragraph X-C or for a period of eighteen (18) months from and after the date of acceptance of redesign work, whichever is later.

E. Should the Contractor fail to promptly make the necessary redesign and accept responsibility for the costs incidental to such redesign for which the Contractor is liable as described in this Article, the Owner may perform or cause to be performed the same at the Contractor's expense.

F. If Contractor personnel are furnished to perform services in connection with or incidental to Preoperational Testing or Start-up, Owner shall, in consideration of Contractor's agreement to relinquish direction and control of such personnel to Owner in accordance with Article II-C above, release, indemnify and hold harmless Contractor from and against all liability in connection with or incidental to the furnishing of such Preoperational Testing Services or the acts or omissions of Contractor personnel or Preoperational Testing, including but not limited to liability for injury to or death of any person or persons and damage to any property, regardless of where located.

G. In addition to the insurance requirements contained in Article XII, the Contractor shall carry and maintain at all times during the term of this Agreement an Engineer's Professional Liability Insurance policy or policies in the aggregate amount of $25 million in any one calendar year to cover claims arising out of error, omission or negligent acts for which Contractor may become liable in carrying out this Agreement and all other agreements for Contractor's professional services.

Prior to the commencement of any work hereunder, the Contractor will furnish the Owner with a Certificate, in duplicate, on the Owner's Form 908 404(S), completed by the Contractor's professional liability insurance carrier, showing that the Contractor carries the requisite insurance and that said policies insure the liability assumed by the Contractor under this Article X.

If at any time Contractor becomes unable to secure, carry and maintain professional liability insurance as above stipulated, Contractor shall immediately notify Owner of such inability to secure such insurance and, in case Contractor cannot satisfy

Owner's requirements, Owner shall have the right to terminate this Agreement.

H. In no event shall Contractor be liable for loss of use, loss of revenue or cost of replacement power.

I. The Contractor will defend the Owner and hold it harmless against and indemnify it for any and all accidents, damages, claims, or costs arising out of any error, omission, or negligent act of the Contractor.

ARTICLE XI INDEMNIFICATION

Except as provided in Article X, the Contractor shall assume full responsibility for the foregoing work and labor and will defend the Owner and hold it harmless against and indemnify it for any and all accidents, damages, claims or costs, whatsoever, occasioned wholly or in part by any act or omission of the Contractor; provided, however, the Contractor shall not be obligated to indemnify the Owner for any accidents, damages, claims or costs which are the result of the sole negligence of the Owner. The Contractor's liability under this indemnity, to the extent that it indemnifies the Owner against its own acts or omissions as a joint tort-feasor, shall be limited as follows: General and Automobile Liability, Bodily Injury limits $500,000 each person and $1,000,000 each occurrence; General and Automobile Liability Property Damage limits $100,000 each occurrence.

If any member of the public, or any employee or agent of the Contractor, or any employee or agent of a subcontractor is injured or killed, or if any property including Owner's or the public's is damaged in the course of work being performed under the provisions of this Contract, Contractor will notify Owner's personnel who is inspecting the work or in his absence Owner's supervisor who originated the Contract. Such notification will be made immediately in person or by telephone and promptly confirmed in writing, and will include all pertinent data such as name of injured party, location of accident, description of accident, nature of injuries, names of witnesses, disposition of injured or deceased person.

ARTICLE XII INSURANCE

The Contractor will carry Workmen's Compensation Insurance as required by statute and will also carry both General and Automobile Public Liability and Property Damage Insurance acceptable to the Owner, in amounts adequate for the job and commensurate with the liability involved, but, in no event less than General Liability Bodily Injury $500,000 per occurrence and $1,000,000 aggregate; General Liability Property Damage $100,000 per occurrence and $200,000 aggregate; Automobile Bodily Injury $500,000 per person and $1,000,000 per occurrence; and Automobile Property Damage $100,000 per occurrence. The Contractor will have the General and Automobile policies endorsed to provide blanket contractual coverage, expressly with respect to Article XI above, to the full limits of and for the liabilities insured thereunder; and, prior to the commencement of any work hereunder, the Contractor will furnish the Owner with a certificate, in duplicate, on the Owner's Form 908 404(S), completed by the Contractor's insurance carrier, showing that the Contractor carries the requisite insurance and that said policies insure the liability assumed by the Contractor under Article XI above.

During construction operations, the Owner shall procure at its own expense a Project Insurance Program for itself, Construction Manager, Architect/Engineer each Contractor, Subcontractor and Sub-Subcontractor embracing Workmen's Compensation and Employer's Liability, Comprehensive General Liability and All-Risk Builders Risk.

Contractor's jobsite permanently-assigned personnel are included in this coverage.

Contractor shall furnish Owner with a Certificate of Insurance as evidence that the foregoing insurance is being maintained. Such insurance shall provide for twenty (20) days' written notice to be given Owner prior to cancellation or material modification of the coverage described therein. In the event this insurance or any portion of it becomes commercially unavailable, Owner and Contractor shall cooperate in efforts to obtain such replacement insurance as may be available and this Contract shall be modified accordingly.

ARTICLE XIII DRAWINGS, PLANS, CALCULATIONS AND SPECIFICATIONS

All drawings, plans, specifications, calculations and/or models developed by or for the Contractor pursuant to this Agreement shall be the property of Owner and shall be delivered to Owner upon completion of the Services or upon termination as provided in Article XIV below, but Contractor may retain and use copies thereof as herein provided. Contractor may use the product of its engineering effort expended on behalf of Owner for its general reference and the enhancement of its engineering capabilities, but shall not market or sell drawings, plans, specifications and models developed pursuant to this Agreement without the prior written approval of Owner. Contractor shall review with and supply copies to the Owner of calculations and analyses developed by or for Contractor pursuant to this Agreement as requested by Owner.

ARTICLE XIV NOTICE AND APPROVAL OF RESTRICTED DESIGNS

Contractor shall, to the extent practicable, make maximum use of products, materials, construction methods, and equipment which are commercially and competitively available or which are available through standard or proven production techniques, methods and processes. Unless approved by the Owner, the Contractor shall not, in the performance of the work called for by this contract, produce a design or specification such as to require in this construction work the use of structures, products, materials, equipment or processes which are known by the Contractor to be available only from a sole source. As to any such design or specification, the Contractor shall report to the Owner's Authorized Representative giving the reason or reasons why it is considered necessary to so restrict the design or specification.

ARTICLE XV <u>FORCE MAJEURE</u>

Neither party shall be considered in default in the performance of its obligations under this Contract to the extent that performance of any such obligation is prevented or delayed by any cause, existing or future, which is beyond the reasonable control of such party.

ARTICLE XVI <u>TERMINATION</u>

A. Owner may terminate Contractor's Services at any time for reason by giving Contractor thirty (30) days prior written notice of such termination, whereupon Contractor shall:

   1. Stop the performance of Contractor's Services hereunder except as may be necessary to carry out such termination as mutually determined between Owner and Contractor; and

   2. Take any other action toward termination of Contractor's Services which Owner may reasonably direct.

B. In the event of termination as above provided, Owner shall pay to Contractor the Fixed Price payments to point of cancellation adjusted to represent the actual percentage of design completion and Recoverable Costs incurred prior to termination and in compliance with Paragraph A above, together with costs reasonably incurred by Contractor as a result of termination as mutually agreed between Contractor and Owner.

ARTICLE XVII SUSPENSION OF SERVICES

Owner may suspend, or extend the time for, the performance of Contractor's Services hereunder, in whole or in part, at any time and from time to time upon ten (10) days prior written notice of such suspension or extension. Thereafter Contractor shall resume the full performance of the Services when directed to do so by Owner.

In the event of suspension or extension of performance of the services beyond sixty (60) days at the Owners request, Contractor shall be entitled to reimbursement for escalation and additional costs reasonably and necessarily incurred by the Contractor due to this suspension or extension. Any escalation of the fixed price caused by this suspension or extension will be calculated as follows:

$$\left(\frac{\text{Index for Payment Month}}{\text{Index for Base Month}} - 1\right) \times \text{Deferred Payment}$$

Index shall be the Contractor's average hourly salary rates for the applicable month as calculated and certified by Contractor's internal auditors.

Payment month shall be the month in which deferred payment becomes payable.

Base month shall be the earliest month from which the payment or a portion thereof has been deferred.

Deferred payment shall be the amount not paid under the original schedule and not previously paid under the revised schedule.

The schedules for performance of the services shall be amended to reflect any such suspension or extension.

In the event any suspension of the Services exceeds a reasonable time, not to exceed one hundred eighty (180) days, Contractor may terminate its obligation to perform the Services by so notifying Owner in writing and the provisions of the Article entitled "Termination" shall apply to such termination.

ARTICLE XVIII NOTICES

Any notice provided for or required hereunder shall, except as specified otherwise in this Contract, be given to the following:

To Owner: Project Manager, Crystal River Unit #4
Florida Power Corporation
3201 - 34th Street South
St. Petersburg, Florida 33711

To Contractor: Black & Veatch Project Manager
Florida Power Corporation, Crystal River #4
P. O. Box 8405
Kansas City, Missouri 64114

or to such other persons or address as either of the parties shall substitute by notice given as herein required.

Such notices shall be given by U. S. Mail, First Class, postage prepaid, and shall be effective upon receipt unless a later effective date is specified therein.

ARTICLE XIX <u>ASSIGNMENT, SUBCONTRACTS AND TRANSFER OF RIGHTS</u>

A. This contract shall not be assigned by any party without the prior written approval of the other, but portions of the Services may be subcontracted by Contractor after Owner's approval of award to a particular subcontractor, associates and consultants.

B. Owner represents that it is the sole Owner of the Project and has sole rights to operate the Project. In the event Owner sells, leases or otherwise transfers ownership, operating rights, or any other interest in the facilities to be constructed hereunder or any part thereof, Owner agrees to require the purchaser, lessee or transferee to provide Contractor with the identical property insurance and liability protection that Owner is required to provide hereunder and to require such purchaser, lessee or transferee to release, indemnify and hold Contractor harmless from and against liability to the same extent Owner has released Contractor from liability or agreed hereunder to indemnify or hold Contractor harmless from and against liability so that neither Contractor's aggregate liability to Owner and such purchaser, lessee or transferee nor Contractor's liability exposure to third parties will be increased by such sale, lease or transfer.

ARTICLE XX EQUAL OPPORTUNITY

A. The Contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and of the rules, regulations and relevant orders of the Secretary of Labor.

B. The Contractor will furnish all information and reports required by Executive Order 11264 of September 24, 1965, as amended by Executive Order 11375 of October 13, 1967, and by the rules regulations and orders of the Secretary of Labor, or pursuant thereto.

ARTICLE XXI APPLICABLE LAW

This Contract shall be interpreted under and governed by the law of the State of Florida.

ARTICLE XXII SUCCESSORS AND ASSIGNS

This Contract shall inure to the benefit of and be binding upon the successors and permitted assigns of the parties hereto.

ARTICLE XXIII ENTIRE AGREEMENT

Any services provided for herein which were performed or caused to be performed by Contractor prior to the effective date of this Contract shall be deemed to have been performed under this Contract. This Contract constitutes the entire agreement between the parties hereto relating to the subject matter hereof, and supersedes any previous agreement or understandings. Contractural terms and conditions contained in purchase orders, work orders, or other documents issued by Owner to Contractor with respect to the Services shall be of no force and effect and shall be superseded by the terms and conditions contained in this Contract except to the extent agreed to in writing by a partner of Contractor.

IN WITNESS WHEREOF, the parties hereto have entered into this Contract on the day and year first hereinabove written.

OWNER: FLORIDA POWER CORPORATION

WITNESSED BY:

_______________________ BY: _______________________

_______________________ TITLE: Director, Purchasing and Stores

CONTRACTOR: BLACK & VEATCH

WITNESSED BY:

_______________________ BY: _______________________

_______________________ TITLE: _______________________

FLORIDA POWER CORPORATION
Risk
Mgmt. Dept.
Approved
Date 6/27/77
By

FLORIDA POWER CORP.
Tax
Accts. Dept.
Approved
Date 6/24/77
By

FLORIDA POWER CORP.
LEGAL DEPT.
APPROVED
Date 6/24/77
By

Technical Paper

Boiler design considerations

J.A. Barsin, Member ASME
Manager, Combustion Systems
Fossil Power Generation Division
Babcock & Wilcox
Barberton, Ohio

Presented to
Coal Combustion Technology and
Emission Control Conference
Pasadena, California
February 5 - 7, 1979

See p. 5

BR-1132

Babcock & Wilcox
a McDermott company

BOILER DESIGN CONSIDERATIONS

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PGTP 79-12

INTRODUCTION

Aspects of Boiler Design relating to Coal Combustion

Why are there so many different styles, shapes and sizes of steam generators? (Fig. 1) Today, I plan to briefly discuss those factors that influence the design of a steam-generating system. Initially, an overview of the major factors will be presented, followed by specific details.

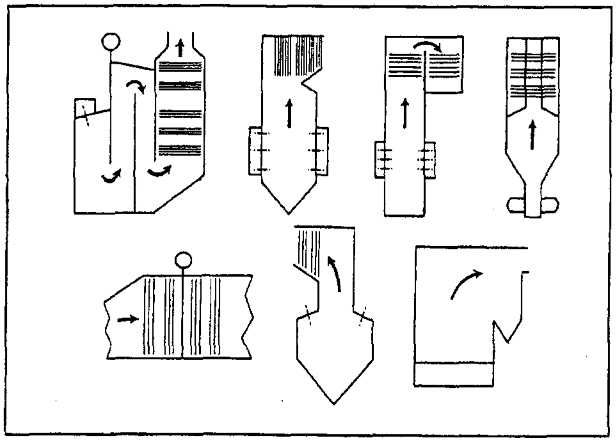

Fig. 1 Types of steam generators

The dominant influence on physical size of the steam generator is the required output as specified by our clients. A unit designed to produce 90 MW electrical output requires a furnace depth of 28' and height of 96'. The furnace required for a 1300 MW output is 51 feet deep and 190 feet high. The widths respectfully are 24 feet vs. 110 feet.

Both units are designed for similar fuels but the entire 90 MW unit could fit easily into the furnace of the 1300 MW size unit.(Fig. 2)

The specifications of our clients dictate the market requirements for capacities required, oper-

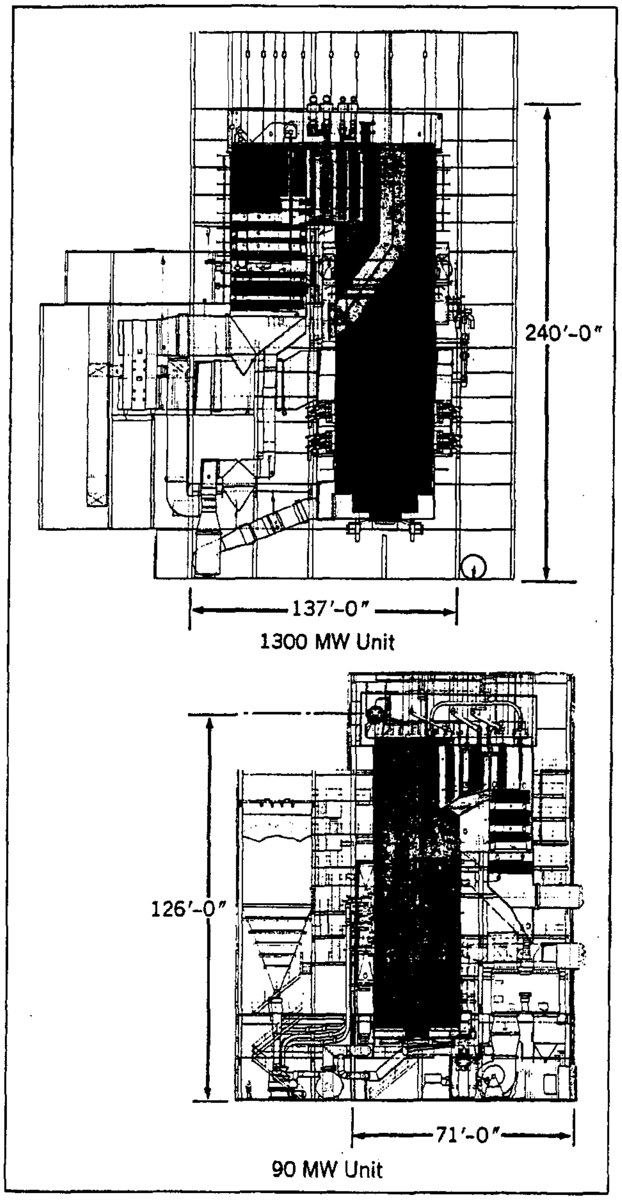

Fig. 2 Size difference due to capacity

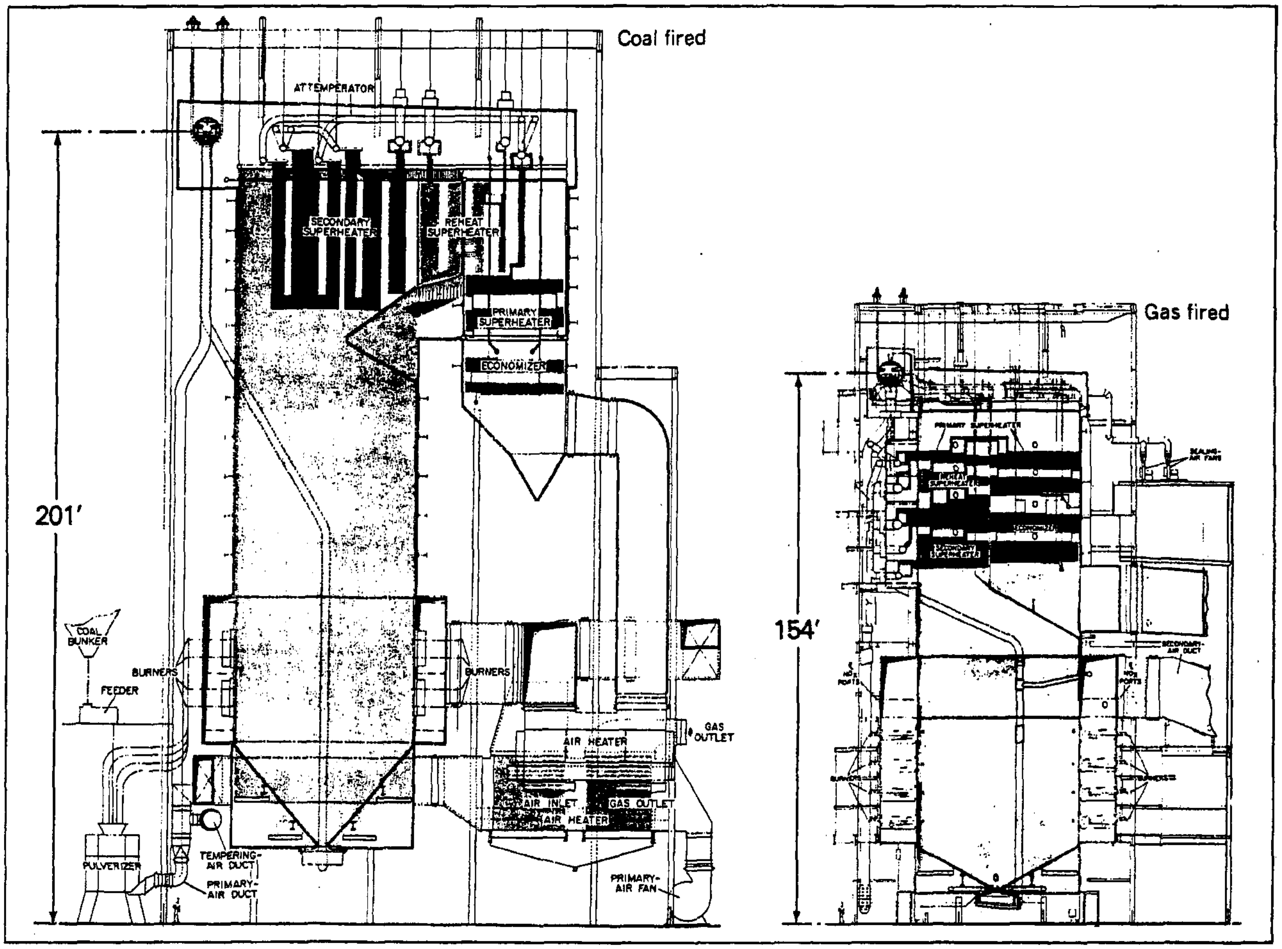

Fig. 3 Size difference due to type of fuel

ating pressures, and temperatures. Grouping all clients together and plotting averages for the past 18 years sometimes allows us to generate "trends" that we as designers can extrapolate and use to develop new equipment to meet future expected needs.

Utility purchasing patterns can be plotted but it is difficult to discern a trend. The 1976 purchasing cycle reached a 16 year low of 5,000 MW worth of fossil units ordered by US utilities and we expect the market demand to rest at 13,000 MW/year through 1982. The reduction in orders is attributed to such factors as a lower projected growth-rate in the use of electrical energy, higher cost of fuels and greater emphasis on environmental considerations.

Availabilities have trended downward and forced-outage rates have increased as a function of unit size. The larger units were predominantly the 3500 psig cycle. The resultant reduction in availability from these first-generation, supercritical generators has revised the cycle preference with a general return to the 2400 psig cycle. The pressure trends forecast the shift from forced to natural internal circulation. The availability improvement experienced with second generation supercritical generators coupled with the rapidly rising fuel costs may initiate a return trend to the lower heat rate cycles.

Size trends always are increasing, but presently they are increasing at a slower rate with 625 MW the average size and 1300 MW the largest size.

Temperature requirements have remained at 1000°F/1000°F due to unresolved metallurgical problems encountered at tube-mean metal temperatures in excess of 1200°F.

The fuel selected and ash fouling or slagging characteristics in the extreme can be almost as size determinate as the output requirements. Fig. 3 demonstrates the size difference between a gas fired and coal fired generator both rated at the same output.

Our clients dictate to us the fuel selection and usually provide us with a range of coals that the steam generator must be capable of firing for sustained MCR operation. However, one coal is, by mutual agreement, specified as the performance fuel and all guarantees are based upon that fuel.

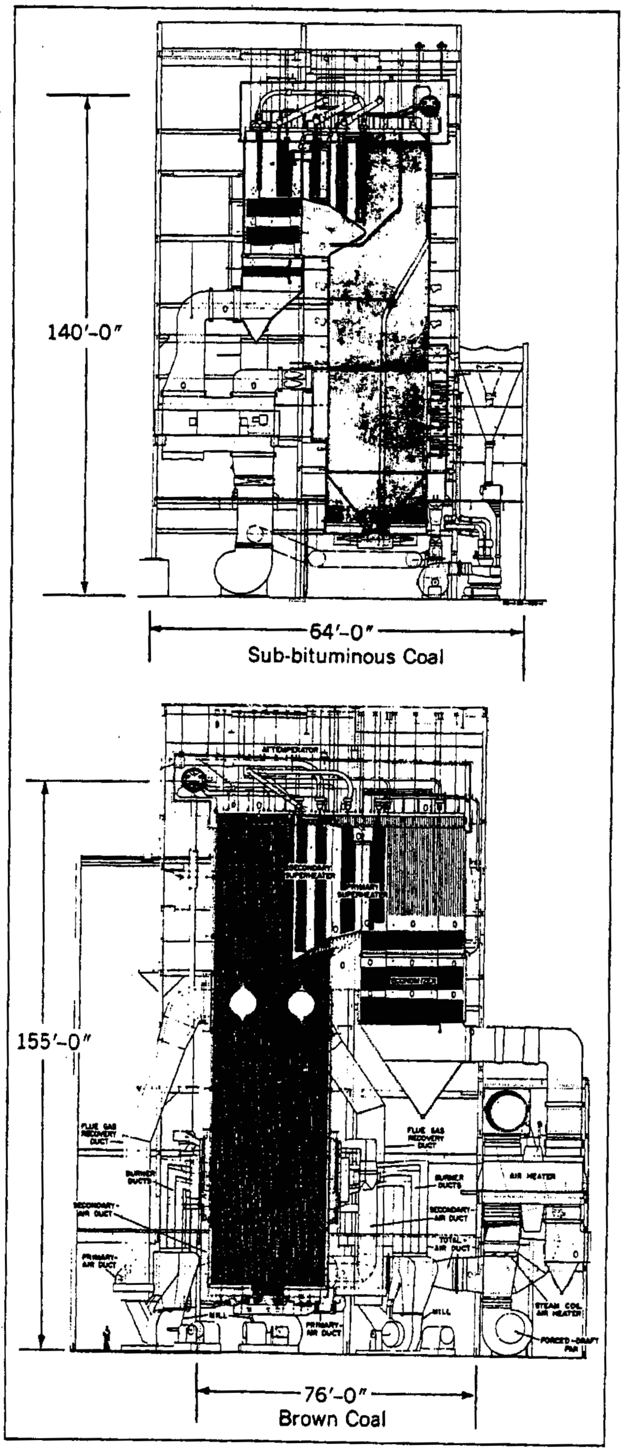

Fig. 4 Size difference due to coal differences

The fuel, in addition to impacting the steam generator size, also influences the furnace configuration.

Fig. 4 demonstrates size differences due solely to the type of coal utilized. The Kosovo plant fires Yugoslavian Brown coal and the Drake 3 plant utilizes subbituminous Western USA coal and both units are rated at 130 MW electrical output.

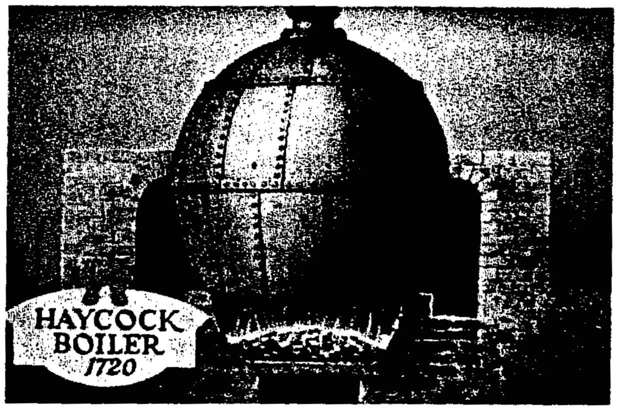

Fig. 5 The Haycock boiler

The Haycock Boiler was designed in 1720 as a saturated steam generator, low pressure, small capacity, grate firing, slow response, and low heat release rates.This generator design was not affected to any great extent by the fuel ash characteristics due to the large furnace and low heat release rates. (Fig. 5)

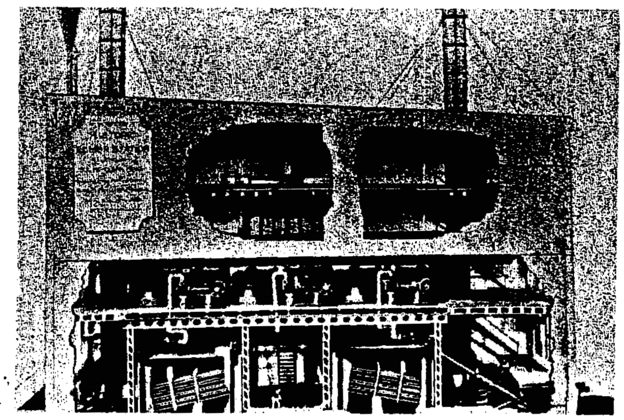

Fig. 6 Historic Edison Station

The Edison Pearl Street Power Generation Station serves to illustrate progress in the state-of-the-art in Boiler Design from 1720 to 1882. Building volume and thereby furnace volume was restricted, the addition of water tubes dependent upon convection heat transfer coupled with requirements for excess air and flow control added to the complexity of the system. (Fig. 6) Restrictions in the form of specifications continued to be placed upon the supplier challenging designers to innovate continuously from 1882 to the pesent.

The previous 16 years (1962-78) fuel range indicates a shift from bituminous to subbituminous and lignites. This is related to geographical load-growth patterns, transportation costs of fuel and environmental factors. National environmental restrictions and oil/gas fuel costs since 1973 have encouraged the trend from alternates to these lower grade coal fuels.

These lower grade fuels require proportionally more pounds through-put for equivalent Btu inputs. The higher mass flow rates and higher ash loadings have forced us to lower gas side velocities to reduce erosion of heat transfer surfaces. The lower velocity requirement tends to widen a unit.

Grindability, ash characteristics, moisture, heating value, nitrogen, in fact all fuel characteristics, impact the design but the ease of ignition and the stability characteristic of the fuel is of the greatest importance when selecting a combustion system.

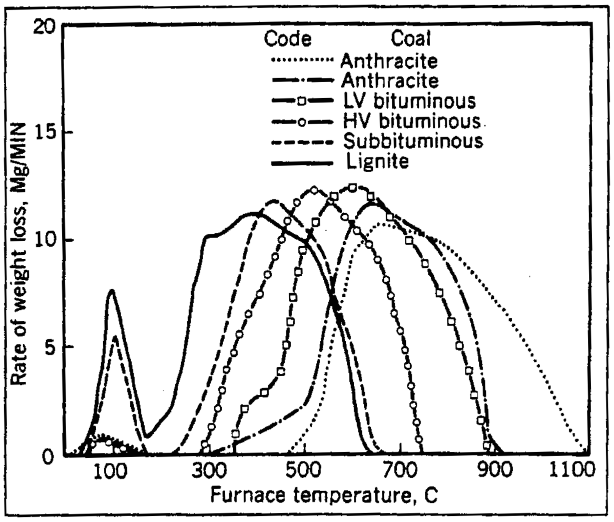

Fig. 7 Burning profiles for coals of different rank

We utilize a "Burning Profile" to characterize each new fuel. The rate of weight loss as a function of temperature when compared to known fuels provides us with the best indication of stability and burnout (residence time) that we have been able to develop. Fig. 7 indicates burning profiles for several very different fuels. The anthracite shown requires a long residence time and its lack of a volatile peak at the 100°C level indicates to us low stability, and therefore, a need for flame recirculation. Fig. 8 indicates the Combustion System that would be applied for this fuel. Peat, Brown Coal and Lignites are at the opposite ends of the profile, but the high volatile peak is due partly to the high moisture, and therefore, they must be treated as having stability problems as well. They do demonstrate a short burnout time and in a unit designed for those fuels, if ash characteristics were not a problem, we would consider reduced residence times. Fig. 8 outlines the combustion system required for a high moisture brown coal utilizing extremely high primary gas drying temperatures and a tower design i.e., ash ladden gas not forced to turn until temperatures have been reduced below 1200°F.

Since 1971 environmental constraints have impacted furnace sizing. The regulation covering NOx emissions, limits pulverized coal fuel NOx emissions to 0.7 #'s NOx/10^6 Btu input. The NOx emitted by a boiler is generated in two ways which are: Nitrogen in the combustion air converting to NO

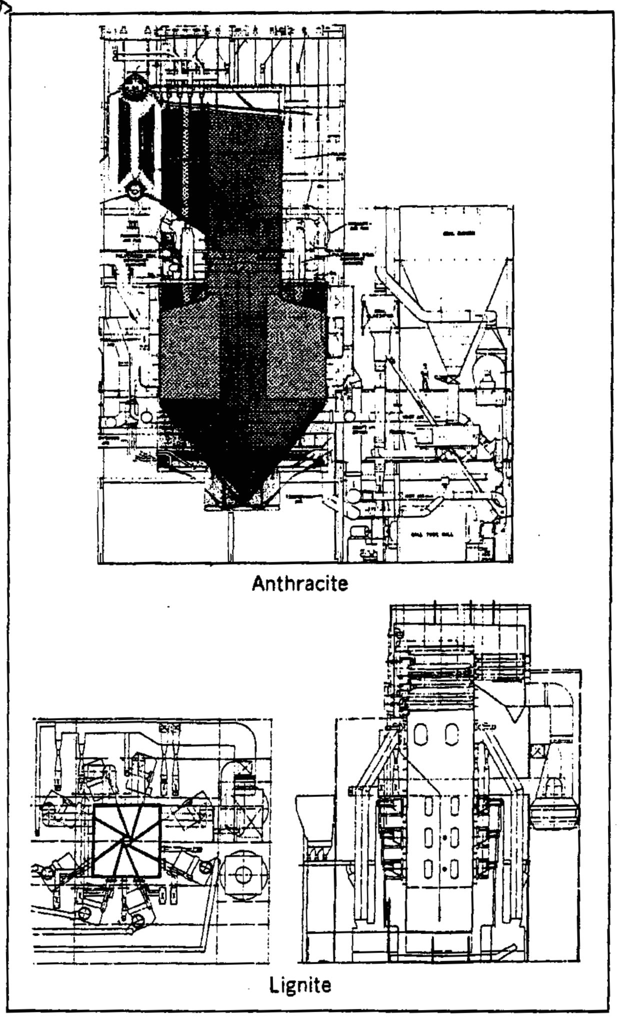

Fig. 8 Differences due to fuel stability characteristics

when in ambients of 2800° F and above (thermal) and the conversion of fuel nitrogen to NO during the combustion process (fuel). Thermal NO reduction may be accomplished by reducing spot flame temperatures to lower levels. The effectiveness of this method using several different approaches has been demonstrated. One approach is to increase the amount of water cooled surface in the flame proximity. The burner matrix is spread out and each burner is separated from its neighbor which results in lower peak flame temperatures but requires larger furnaces. The change in furnace size due to environmental design considerations is demonstrated in Fig. 9.

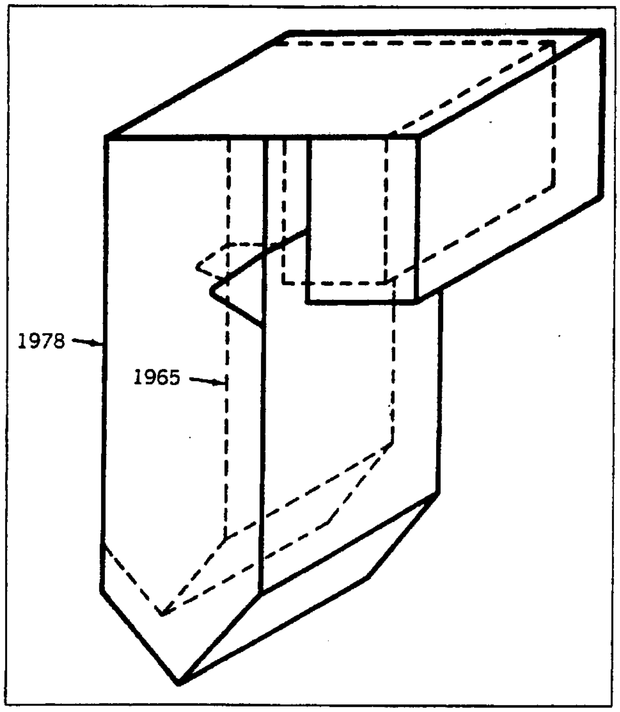

Fig. 9 Size inflation to compensate for environmental considerations

FUELS

The fuel is coal but what type? The trend indicates that low sulfur subbituminous usage will increase. However, this trend, initiated partly by the Clean Air Act of 1971 will probably be slowed by the revisions contained within the proposed New Source Performance Standards of 1978. Typical open pit and strip mines are the most common techniques used to exploit the western fuel deposits. The distribution of coal across the U.S.A. indicates predominate deposits of bituminous in the east and subbituminous/lignites in the north central, west and southwest areas.

We know quite a bit about Eastern U.S.A. bituminous coals since they have been extensively utilized for the past 150 years for steam production. Empirical and experimental indices based upon the ash makeup and relative distribution of constituents have been established and verified which predict slagging and fouling potentials. The application of those indices influence our steam generator designs. The heat content and grindability determine the number of pulverizers and the type of pulverizer required. The burning profile indicates the relative stability and residence time required for that fuel which decides the type of combustor and furnace configuration. Moisture content determines required drying primary air temperatures (steam generator internal heat balance). The fuel nitrogen now influences furnace sizing, burner selected and excess air control requirements.

What is Bituminous Coal? We have defined it from the ash characteristic rather than strictly from the ultimate or proximate analyses. It is bituminous ash by our definition when the ratio of iron (Fe_2O_3) to the sum of calcium (CaO) and magnesium (MgO) in the ash is greater than one.

$$R_S = \frac{\text{base}}{\text{acid}} \times S$$

Slagging

Type	Index Rs
Low	< 0.6
Medium	0.6-2.0
High	2.0-2.6
Severe	> 2.6

$$R_F = \frac{\text{base}}{\text{acid}} \times Na_2O$$

Fouling

Type	Index RF
Low	< 0.2
Medium	0.2-0.5
High	0.5-1.0
Severe	> 1.0

Fig. 10 Indices for bituminous ash

The pertinent slagging and fouling indices are (Fig. 10) based upon the Base to Acid Ratio of the ash constituents modified by the sulfur content in the slagging case and by the Na_2O content in the fouling situation. The levels associated with high or severe are based upon experience gained over the past 100 years and are progressively refined. We might be unpleasantly surprised by a new bituminous ash but the probability is low.

The applicable slagging index level that is utilized directly affects the plan-area maximum permissible heat release in the furnace; or stated more directly - the furnace size, the number of furnace mounted sootblowers and the allowable minimum side spacing of furnace plattens. The fouling index applied affects the clear side spacing in the convection pass, maximum allowable furnace exit gas temperatures and the number and location of sootblowers.

The fuels trend indicates that increasing quantities of subbituminous and lignites will be fired as population shifts and NSPS continue to change. Our experience on these fuels are extensive but not as complete as with bituminous. The lower heating value will require more pounds per hour throughput (Fig. 11) and when coupled with the lower grindability will require a greater number of pulverizers than an equivalent electrical output Bituminous fired steam generator. The higher inherent moistures will require hotter primary air (drying) temperatures, resulting in surpressed flame temperatures that reduce local furnace absorptions, and reduce ignition stability during low load and cold startups. This reduction in ignition stability is somewhat offset by the normally higher primary air temperatures require hotter flue gases which impacts the steam generator's internal heat balance.

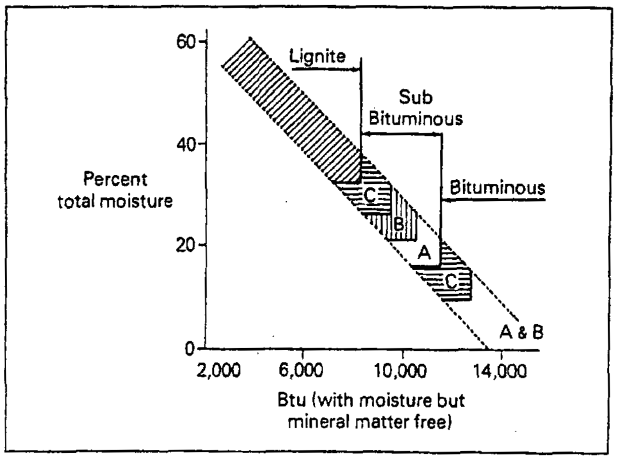

Fig. 11 Coal ranking

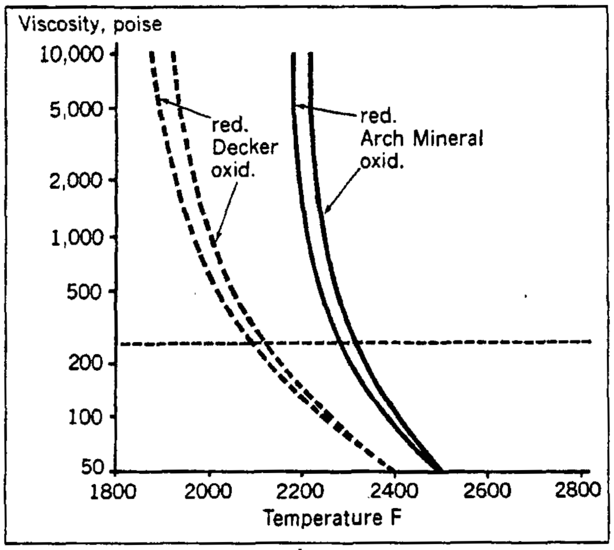

Fig. 12 Viscosity temperature relationships

Lignite type ash, a term which covers most of the subbituminous and lignite fuels in the U.S.A. has been defined by us to exist when the Fe_2O_3 to MgO + CaO ratio is less than one. Several slagging indices have been developed to explain observed phenomena and they are based upon the expected or measured fluid temperature of the slag. It is known that if the slag is wet (fluid), it can be moved about by sootblowers, but not removed. If slag is allowed to accumulate on the lower furnace walls, furnace exit gas temperatures rise and the slagging area is forced higher into the furnace. This can increase deposit temperatures further downstream which increases deposit hardness. The flow properties of slag at various viscosities were studied in the fluid, plastic and solid ranges. Those studies have resulted in the T_{250} and $T_{10,000}$ relationships plotted (Fig. 12) for two different fuel ashes. The wall temperatures must, by design, be kept below the temperature, corresponding to the 10,000 poise level. The slagging index bases can use fusion temperatures or actual measured viscosities produced from laboratory ash. The effect upon furnace size from the index selected can be drastic as may be noted from Fig. 13. This increase in size is strictly for slag control reasons.

Fuels with lignitic type ash have demonstrated fouling potentials related to the Na_2O levels in the coal ash. (Fig. 14) These levels have been indexed and 6% Na_2O level and above for North Dakota Lignites is considered severe fouling by us. The boiler designer is forced to decrease furnace exit gas temperatures, increase the number of sootblowers, increase the clear side spacing, and relocate tube metal surfaces as possible to have the

fix

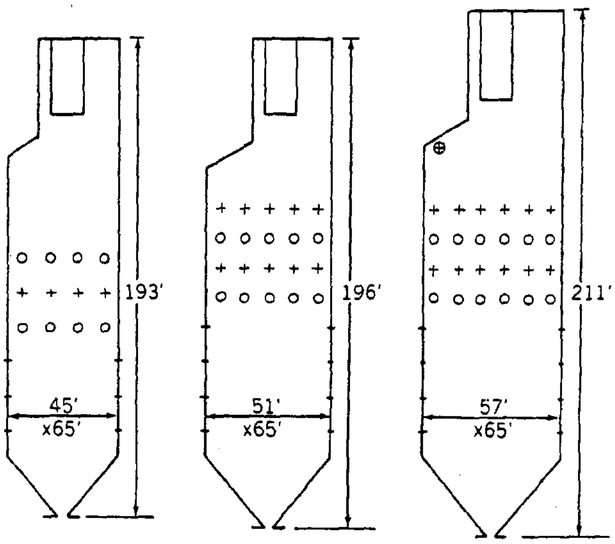

Fig. 13 Influence of ash characteristics on furnace size

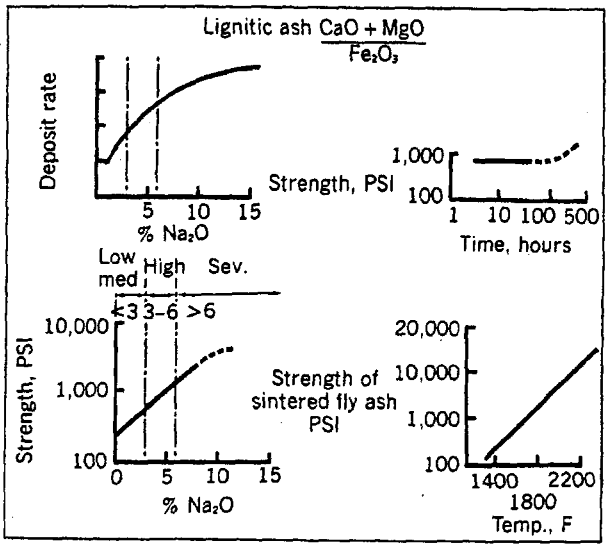

Fig. 14 Fouling

coldest metal in the highest gas temperature zone. Removal of the deposit becomes progressively more difficult with time firing a bituminous coal but lignitic ash deposit removal difficulty does not vary with in situ time.

We are in the process of developing a new (another) slagging/fouling index for certain fuels that match the ASTM requirements for subbituminous classification but whose ash characteristics follow these of border line bituminous/lignite behavior. Fuels that presently fall into that classification are those with low base to acid ratios and low sulfur.

The constant invention of new indexes to explain and predict the ash behavior of new fuels is not a satisfactory design tool from my point of view. Therefore, I commit to supporting K. Hein's (RWE) suggested international effort to standardize slagging and fouling indexes for all coals on this earth, by utilizing a standard reporting format — based upon moisture and ash free reportage.

TEMPERATURE AND CIRCULATION

Availability statistics have encouraged the trends towards the 2400 psig 1000°F/1000°F cycle. As the pressure and temperatures increase the total unit absorption progressively decreases because of increased cycle efficiency. (Fig. 15) The boiler and economizer absorption represents the amount of heat added to the entering feedwater to produce saturated steam. As the operating pressure increases, the amount of heat required to produce saturated steam decreases. Conversely, the amount of heat required for superheat and reheat increases as the pressure increases. The figure has been plotted using the 2400 psi 1000/1000F turbine throttle conditions as the base for 100% total output. The change in required boiler/economizer absorption may not seem significant until it is realized that a 1% shift in absorption is equivalent to approximately 10 degrees of both superheat and reheat.

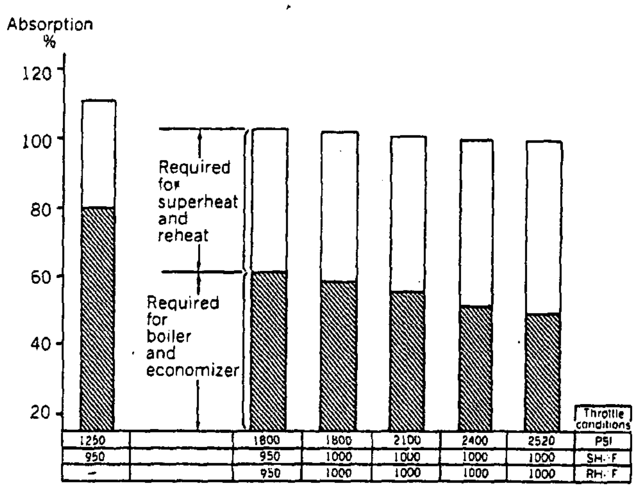

Fig. 15 Distribution of heat absorption

On a drum unit, the furnace and water-cooled convection pass enclosure walls are the boiler surface. On low pressure units, the amount of heat absorbed in the furnace is usually not adequate to produce all the saturated steam required, and a boiler bank is installed after the superheater. On a modern high pressure generator, the heat absorbed by the furnace and economizer is adequate to produce all the saturated steam required.

What happens if the furnace is further enlarged to reduce furnace exit gas temperature? In essence, too much saturated steam would be produced and there would be insufficient heat left in the flue gas to make design superheat and reheat steam temperature.

To illustrate, observe the amount of heat required for the superheater and reheater. A simple heat balance may be made for the superheater and reheater,

$$Q_{steam} = Q_{Gas} \quad (1)$$

$$Q_s = wg\,(Cg)\,(Tg1 - Tg2) \quad (2)$$

which states that the heat absorbed by the superheater and reheater equals the heat given up by the gas. For the boiler shown in Fig. 16, where the furnace is all boiler surface, the gas side can be defined as shown in Equation 2.

where:

Qs = Heat absorbed by the superheater and reheater (Technically, heat absorbed by water cooled walls and screens downstream of the furnace exit while not significant must be added to the superheater and reheater requirements).

Wg = Weight of gas flowing over the superheater and reheater.

Cg = Specific heat of the gas.

Tg1 = Gas temperature leaving the furnace or entering the superheater.

Tg2 = Gas temperature leaving the last superheater or reheater bank.

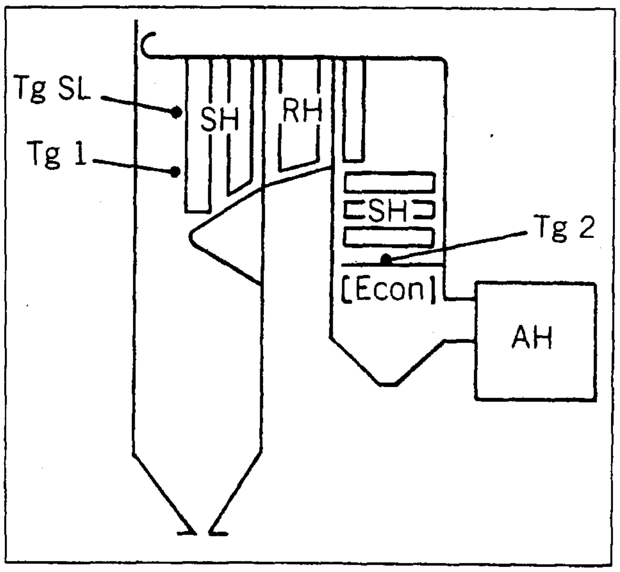

Fig. 16 Gas temperature limits for SH and RH absorption

Steam enters the last superheater bank at essentially saturation temperature, a temperature level which increases with drum pressure. Obviously, for heat transfer to take place from the gas to the steam, the gas temperature leaving the last superheater bank (Tg2) must be higher than the entering steam temperature. There is an economic and functional minimum temperature difference between Tg2 and saturation temperature on the order of 125 to 180 F. Thus a minimum value of Tg2 can be defined. Referring back to Equation 2, ~~it~~ can be seen that the cycle requirements for superheat and reheat absorption combined with an economic and practical limit on the gas temperature leaving the last superheater bank (Tg2) establish the minimum gas temperature leaving the furnace (Tg1) and thus the maximum furnace size and/or absorption.

The relative change in minimum furnace exit gas temperatures versus typical heat cycles is shown in (Fig. 17) for three classes of coals. For a constant boiler output the gas weight and specific heat of flue gas are higher for the subbituminous and lignite coals than for a low moisture bituminous coal. Therefore, those fuels offer the potential to design for lower gas temperature levels than a bituminous coal and maintain similar final steam temperatures.

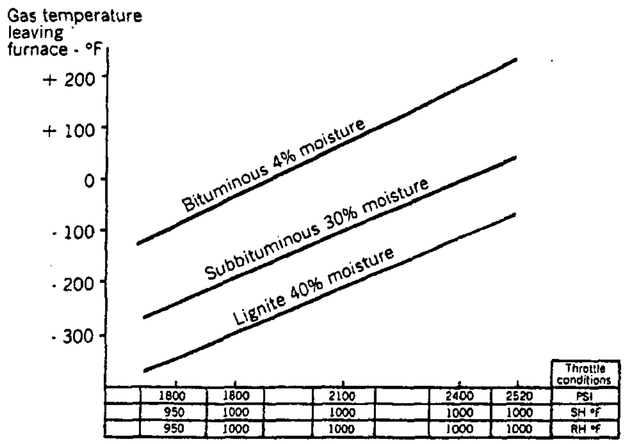

Fig. 17 Relative gas temperature leaving furnace vs fuel type and turbine cycle

The maximum permissible gas temperature (TgSL) is based on the slagging and fouling characteristics of the fuel and can be superimposed on this plot (Fig. 18.) For the lower pressure/temperature cycles, (not now in common usage) the maximum allowable gas temperature limit (TgSL) is higher than the required gas temperature (Tg1) for superheat and reheat absorption. To design a unit to satisfy both conditions (slagging limits and final temperatures) is not a problem. However, what can be done for the higher pressure/temperature cycles (now most common) when the maximum temperature limit for slagging and fouling (TgSL) is less than the temperature required for superheat and reheat (Tg1)? More complicated control methods must be utilized to assist in obtaining full cycle steam temperatures in this situation and the most common are:

1. Replace water cooled furnace surface with steam cooled (superheat) surface.
2. Recirculate flue gas.
3. Burner manipulation.
4. Gas bypass and damper control.
5. Spray attemperation.
6. Excess air.

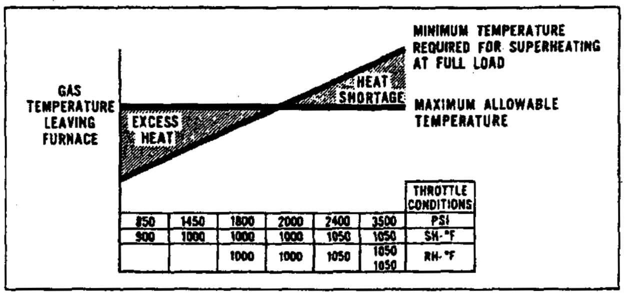

Fig. 18 Required gas temperature leaving furnace

1. Steam-Cooled Furnace Surface

With the first method, superheat and/or reheat surface is utilized in the furnace area. This surface is located high in the furnace and may be in the form of platens on wide spacing which essentially shield the furnace walls and reduce water wall absorption. Since platen surface is located in relatively high gas temperature zones, the side spacing must be sufficient so that bridging is avoided.

2. Recirculated Flue Gas

Referring again to Equation (2), it can be seen that if the gas weight is increased, the minimum gas temperature leaving the furnace (Tg1) can be reduced while maintaining the same overall heat available for superheat and reheat absorption. One method of accomplishing this is to recirculate flue gas from the economizer outlet back to the furnace. This has the effect of reducing gas temperature Tg1 which results in meeting the desired gas temperature level with a smaller furnace. When gas is introduced into the upper furnace, it is designated as tempering. Gas introduced at this location reduces the gas temperature by dilution of the hotter furnace gases entering the tempering zone from the lower furnace with the cooler recirculated flue gas (tempering) while not appreciably changing furnace absorption.

When gas is introduced into the bottom of the furnace (gas recirculation), the gas temperature levels throughout the furnace are reduced due to the dilution of the hot gases by the cooler recirculated flue gas resulting in a reduction of furnace absorption. Because furnace absorption is reduced, the reduction of furnace exit gas temperature is less for gas recirculation than when the same flow rate is introduced as gas tempering into the upper furnace (where furnace absorption is not affected). Typical full load gas temperature levels will show a net reduction in furnace gas temperature for gas recirculation as well as for gas tempering. However, it can be seen that if gas recirculation is exchanged for gas tempering, the gas temperature leaving the furnace will increase. This phenomenon is useful for extending the steam temperature control range at reduced loads. When gas tempering is employed, gas recirculation is normally used for steam temperature control at reduced load.

The two primary deterrents for the use of gas recirculation and tempering from coal firing are:

a. Maintenance of the gas recirculation fans.
b. Power consumption at high loads where tempering is required.

3. Burner Manipulation

The proportion of heat required for steam generation can be modified by forcing the combustion zone higher or lower in the furnace, either through bias firing, tilting burners, or taking burners out of service. The more general procedure is to raise the elevation of the combustion zone at reduced loads to sustain higher steam temperatures. A second option is to lower the elevation of the combustion zone near maximum load to increase the ratio of steam generation vs. steam superheating.

4. Gas By-Pass and Damper Control

This control means has also been used on non-reheat units as shown in (Fig. 19). The balance between steam generation and steam superheating is achieved by controlling the proportion of gas flow over the economizer and the superheater. Most often today this control-means is applied to boilers serving high efficiency cycles for distributing the flow over superheater or reheater surface over the load range with the proportion required for reheating increasing as the load is reduced.

5. **Spray Attemperation**

This method has been widely used in the past on non-reheat cycles. The superheater surfaces are set at the required control load. As load increases, the required proportions are disturbed and the superheater receives too much heat. The excess superheating is balanced by spray attemperation resulting in steam generation in the superheater; thereby, establishing the desired balance without changing the amount of actual furnace absorption. Today spray attemperation is often used for superheat temperature control where other means are used independently for reheat temperature control. When the superheater is designed to provide for increased reheater absorption at reduced load, the resulting higher superheater absorption, at control load, is controlled by attemperation or steam generation in the superheater.

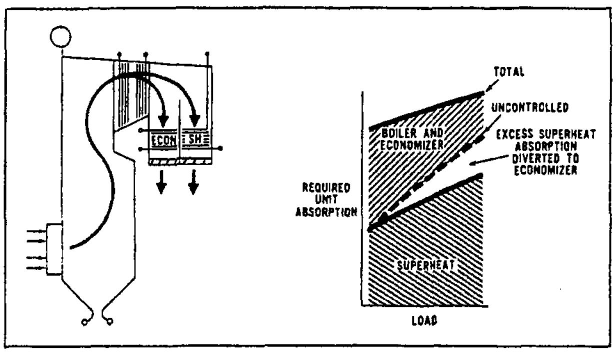

Fig. 19 Gas By-Pass and damper control

Spray attemperation at the reheater inlet is reserved for emergency or unusual conditions, since the resulting steam generation is at a significantly lower pressure (IP turbine inlet) which reduces cycle efficiencies. Superheater spray attemperation also affects cycle efficiency negatively when the spray water source by-passes the HP regenerative feedwater heaters.

Circulation

The furnace must be cooled to avoid overheating the containment tubes. The circulation loop utilized to absorb heat maintains a subcooled water-feed from the steam drum to all the furnace tubes (Fig. 20) The absorption increases the mixture enthalpy and a steam/water mixture is returned to the drum for separation and recycling. The density differential between the subcooled feed and the steam water mixture provides the pumping head in a natural circulation system. An alternative system is forced or pumped circulation and this is an option at 2850 psig drum pressures but must be employed at furnace operating pressures in excess of 3100 psig.

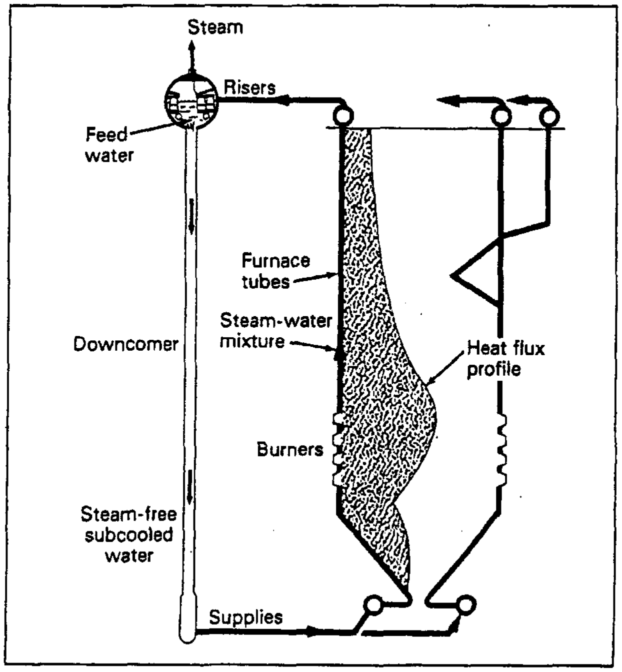

Fig. 20 The circulation loop

B&W utilizes an internally ribbed tube (Fig. 21) which increases internal turbulence and thereby the margin between heat flux and percent steam by weight limitations that could lead to DNB and subsequent tube failures from overheat. Natural circulation does adjust itself automatically to variations in heat absorption in a furnace so that the tube receiving the most heat receives the most water.

Knowledge of the furnace absorption rate pattern, both vertical and peripheral, is most important in the circulation design of large furnaces. The absorption distribution profile depends on, a) the fuel and ash deposition characteristics, b) the type of burners and their relative location, c) the heat input per plan area of furnace, d) the burner zone heat release rate, e) the excess air, and f) gas recirculation where applicable.

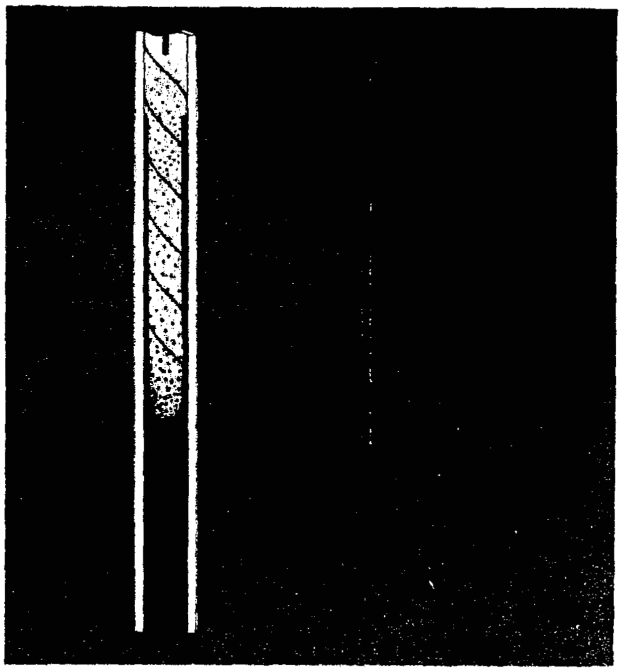

Fig. 21 DNB advantage of ribbed tube over smooth tube

There are under development and in experimental use several fairly good two-phase flow heat transfer furnace models. Our code is based upon empirical data collected over the years and was originally developed to predict the vertical absorption rate distribution pattern within a furnace as depicted in Fig. 16. The vertical heat distribution pattern predicted by the program agrees well with extensive full scale field data and is fully verified. The program is also capable of predicting changes in furnace absorption (FEGT) resulting from bias firing and burner manipulation and the results have been confirmed with field data. Main features of the program are:

1. The furnace is divided vertically into zones.
2. The gas emissivity in each zone is calculated per emissivity curves for CO_2 and H_2O as published in McAdams. That calculated emissivity is a function of the concentration of CO_2/H_2O, gas temperature, and mean radiating length.
3. The emissivity can be and usually is modified so that the overall furnace absorption conforms with a known or base set of conditions.

It is recognized that the adiabatic temperatures calculated in each zone are not an accurate picture of the actual process, but the resulting average burner zone absorption agrees well with field data.

The general shape of the inherent vertical and lateral absorption rate pattern has moderate variation with load or firing rate and is consistently reproducible. The magnitude of the local heat flux in the furnace does change, however, with the heat input. Absorption tests have shown that an additional noncontinuous variation of local heat absorption rate at each load is superimposed over the inherent, steady pattern. The noncontinuous heat absorption deviations are due to operational variables such as unbalanced firing, changing slagging conditions, load swings, selected sootblowing, pulverizers out of service, fan outages, etc. The magnitude of the heat upset factor depends on operational conditions, firing arrangements and fuel slagging characteristics.

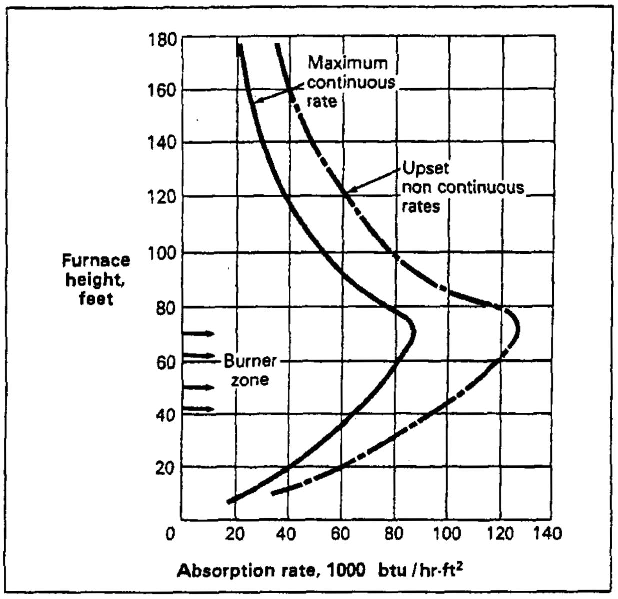

Fig. 22 Heat absorption rates along furnace front wall tubes

Fig. 22 shows the maximum continuous heat absorption rate and the highest upset noncontinuous heat absorption rate over the furnace height calculated for the unit shown in Fig. 16. The peripheral inherent heat absorption distribution is shown in Fig. 23. This pattern remains similar even when pulverizers are removed from service, since each pulverizer feeds burners of the same level across the entire furnace width. In large natural circulation furnaces, the use of many low heat input burners equalizes the heat absorption pattern of the furnace walls.

The flow calculations for each furnace circuit are based not only on the expected heat absorption rate along the tubes, but also on two possible extreme heat absorption rates. The lowest heat absorption rate determines the expected minimum mass velocity while the maximum heat absorption rate determines the highest quality; and both values are used to establish the DNB limit of the circuit.

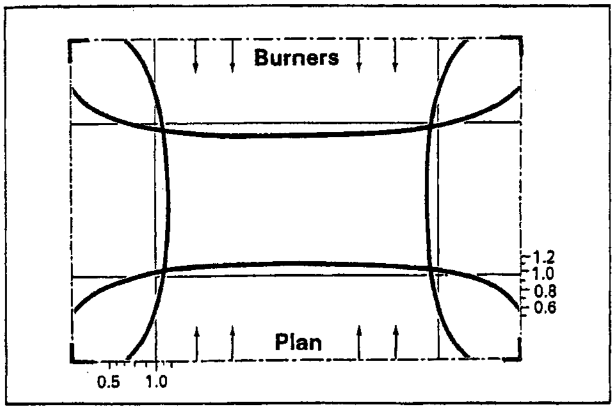

Fig. 23 Horizontal distribution of heat absorption in furnace walls

The typical values for average and maximum steam qualities over the height of the tubes in the furnace are shown in Fig. 24. Because of the compensating feature of natural circulation-increased flow when more heat is absorbed - the spread between the maximum and average steam quality is smaller with natural circulation than with pumped circulation. The top of the burner zone where the heat flux is the highest is the most critical location in the furnace. The maximum quality at this level is usually limited to about 20 percent SBW.

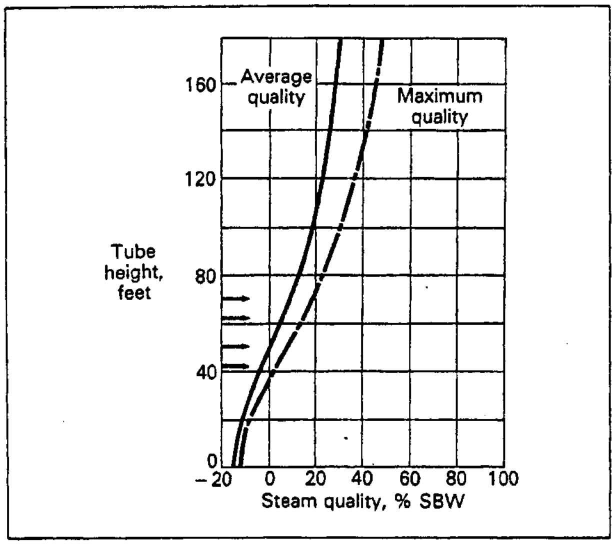

Fig. 24 Steam quality along tubes

COMBUSTION SYSTEM

The combustion system selected must be capable of providing ignition stability, complete carbon burnout, minimize spot absorption upsets, aid in controlling slag deposition, minimize excess air requirements, rapidly respond to load changes, accept large (± 10%) variations in fuel quality, provide suitable turndown, aid in controlling FEGT's and now control NO emissions. The major elements of the combustion system are the pulverizer, burner, furnace and air flow control, all of which have been deliberately darkened in Fig. 25 to demonstrate the major effect that system has upon boiler design.

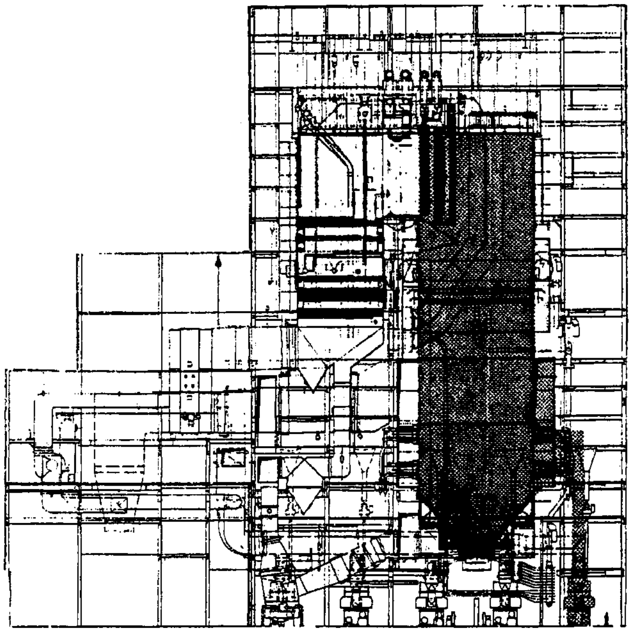

Fig. 25 Components of a combustion system

Pulverizers

The system starts with the pulverizers which supply coal at the required fineness to the burners. The required fineness has been empirically determined from experience and laboratory work and ranges between 85% passing thru a 200 mesh requirement for a low volatile high ash anthracite to 60% passing thru a 200 mesh requirement for a high volatile low ash lignite Those values are the best current economic trade-offs to obtain the maximum carbon utilization, minimize stability and slagging problems with acceptable fuel preparation costs.

The roll and race mill (Fig. 26) is applied to a range of fuels containing moistures below 50%, and is our principle high capacity mill for domestic fuels. In this design, raw coal enters the mill at the top center and falls by gravity to the grinding zone. The primary air passing through the mill throat at high velocity picks up the partially ground coal and carries it to the classifier. The classifier rejects large coal particles to the grinding zone and allows the fines and primary transport air to continue out of the mill to the burners. The primary air performs a dual function in addition to transporting the coal and preventing the mill from choking with coal, it must evaporate moisture from the ground coal. This drying is accomplished by supplying the P.A. at a high enough temperature to insure that the mill outlet temperature to the burners does not drop below 135°F for a high volatile fuel. Lower volatile fuels require higher mill outlet temperatures to enhance flame stability. Mechanically, the pulverizer must produce a uniform product over its wear life cycle.

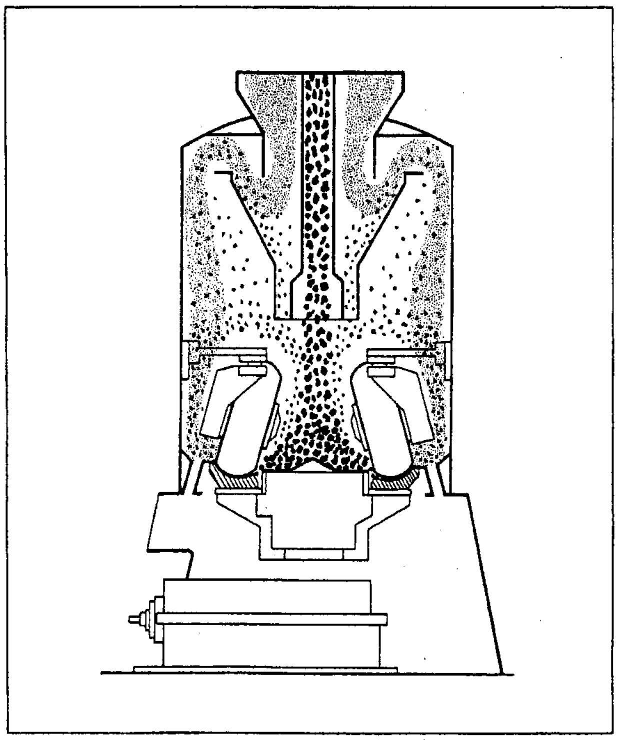

Fig. 26 Coal recirculation

If the fineness varies, i.e., drops off as the wear cycle increases clearances the % passing 200 and % passing through a 50 mesh screen will decrease and larger coal particles will be produced. Slagging and higher carbon will result. Functionally, it would be an excellent tool to be able to vary the Primary Air Ratio to coal over the pulverizer load range to: A) vary stoichiometry in the primary flame zone, and B) increase richness of mixture for stability at cold conditions. The pulverizer throat, however, is a constant opening and requires a minimum velocity to prevent drible (coal dropping out of the grinding zone), and the transport pipes to the burners require minimum P.A. velocities to prevent coal dropout in the lines. If the throat is sized for a minimum Primary Air Flow, pressure drop is excessive (evaluated cost) at full mill load. The same holds true for the coal transport lines - if sized for the minimum P.A. flow, pressure drop is uncompetitively high at full mill load. One approach to control the PA/coal ratio in the initial zone would be externally adjustable classifiers on the coal lines from each mill. We are developing this approach but customer acceptance will not be overwhelming unless the benefits (reduce auxiliary fuel consumption, lower NOx) outweigh the liabilities (high maintenance item due to erosion, vent line pluggages, and increased capital and operational costs). The roll and race mill is adequate at present but if the fundamental studies now in progress confirm the importance of Primary Flame Stoichiometry, additional external equipment will be required.

A second pulverizer that we use is the DGS mill which is a high speed beater type and is applied to high moisture fuels.

Tube mills are applied to abrasive fuels but have a somewhat slower response rate. Whichever mill is selected it must not allow fineness to drop off as the wear cycle progresses.

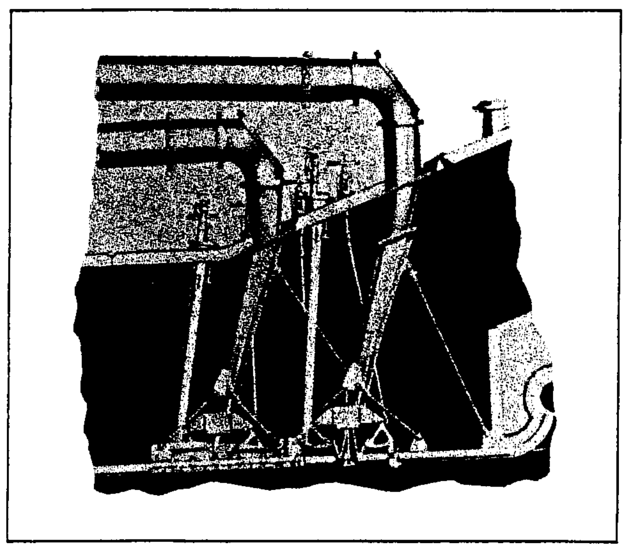

Fig. 27 Down shot burners

Burners

The burners are the second major component in the combustion system. The intertube pulverized coal burner (Fig. 27) did not mix at the burner and depended upon the furnace for air fuel mixing and residence time to minimize carbon loss. Displacing that vertical-firing downward burner was our highly turbulent circular burner, arranged horizontally opposed. The cell burner (Fig. 28) followed which continued the high turbulence trend to minimize required furnace residence times. All three of these burners initially were laboratory-developed in test tunnels and then field retrofitted prior to release as commercial products. Inputs were constantly increased as steam generator sizes increased until the three nozzle cell burner was capable of releasing 500 x 10^6 Btu/hour within a 6 x 12 foot area.

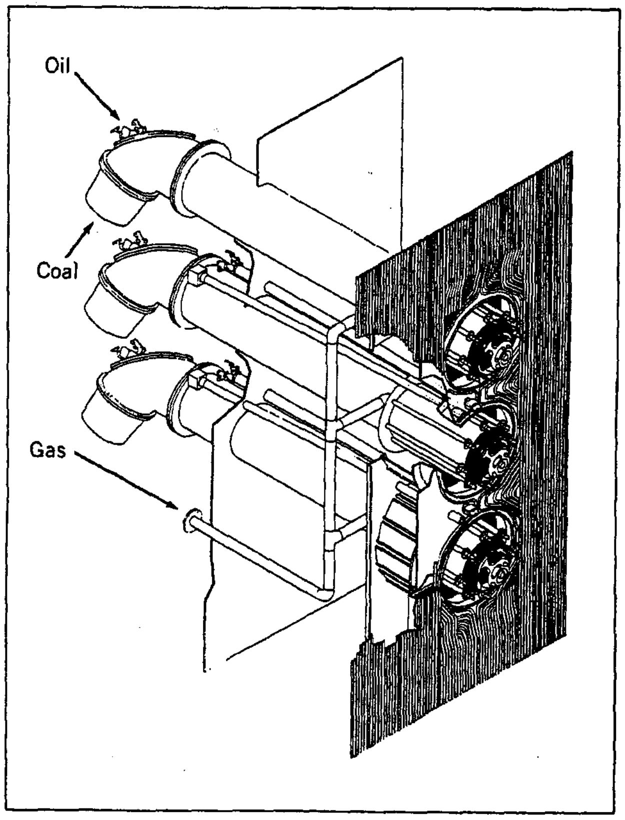

Fig. 28 Cell burner—coal, oil and gas firing

During this same time period, corner firing was utilized by Babcock for high moisture/severe slagging fuels. This system was selected to minimize required turbulence and maximized the use of the furnace to aid in mixing. (Fig. 29). The resultant "slow" combustion was extremely successful in maintaining stability and reducing peak flame temperatures which aided in reducing slagging. In this country, tangential firing utilizes similar principles but, in addition, has been designed to allow vertical burner tilt which aids in maintaining a more constant FEFT.

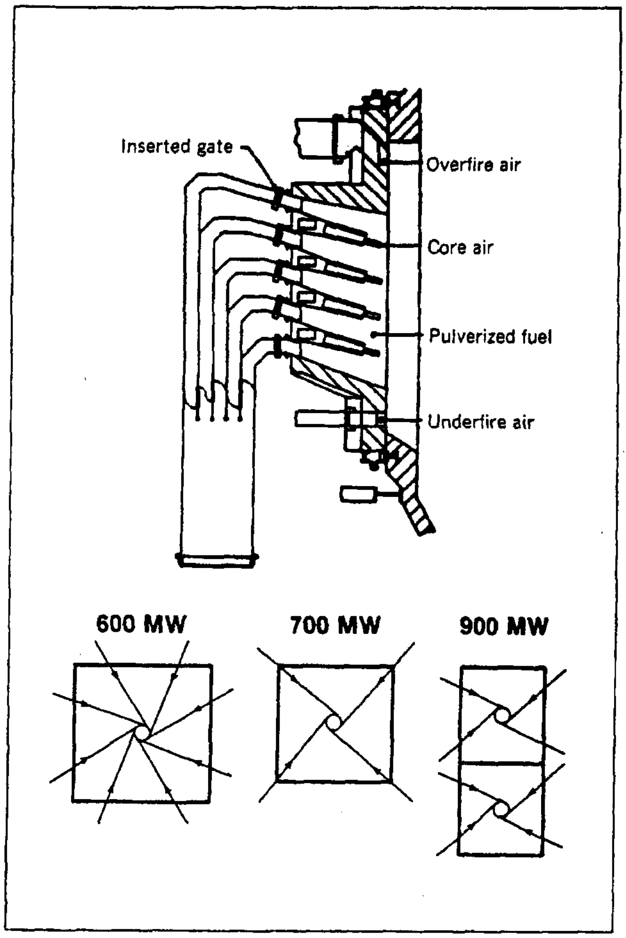

Fig. 29 Babcock brown coal firing system

Environmental considerations have encouraged us to reduce burner turbulence and, as a result, increase furnace size to increase residence time. The Dual Register burner (Fig. 30) was conceived to meet this need and has proven in field tests to be a successful development. Similar burner development work is being carried out by other suppliers along with the application of two-stage combustion for their commercial offerings.

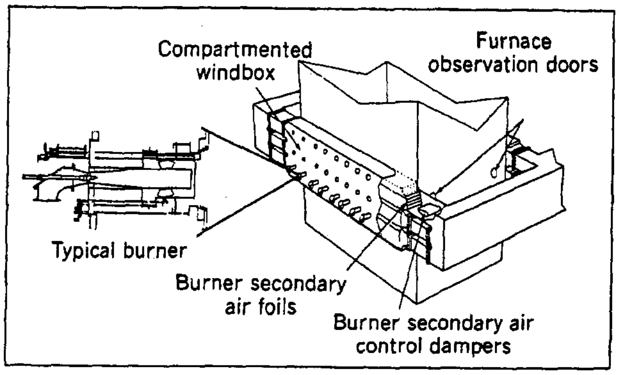

Fig. 30 Dual register burner compartmented windbox system

Compartmented Windbox

The third major element in our combustion system is the air supply for combustion. The application of the compartmented windbox philosophy to oil-fired units was successful in obtaining very low excess air operation. The amount of excess air contributes directly to the formation of NO from both thermal and fuel mechanisms, and therefore, tighter excess air control on pulverized coal became important when NOx emissions were regulated. The means to control air flow on a pulverizer basis had always been available but competitive pressures precluded application during the 1960's.

Application of the compartmented windbox permits control of fuel and air flows to each burner group. This provides the flexibility to operate with low excess air and maintain an oxidizing atmosphere around each burner. The result: lower NOx emissions and increased flexibility for slag control.

Furnace

The fourth major element in the combustion system is the furnace. Earlier, we discussed the need to size the furnace adequately for slag control, but pointed out that the resultant heat available to the superheater or reheater might not be sufficient over the load range to meet required final temperatures. Now two new elements in furnace sizing criteria must be considered. These are:

A) Increased residence time for the fuel because of reduced burner turbulence and,
B) Decrease in spot flame temperatures required to minimize NO formation from thermal mechanisms.

The burner zone furnace size has increased from 8215 ft^2 to 13,494 ft^2 for two steam generators with similar capacity, (eliminate capacity sizing) the same fuel (eliminate slag control sizing) but one (1960 design) did not have to meet and would not have met the NSPS of 1971 (Fig. 31)

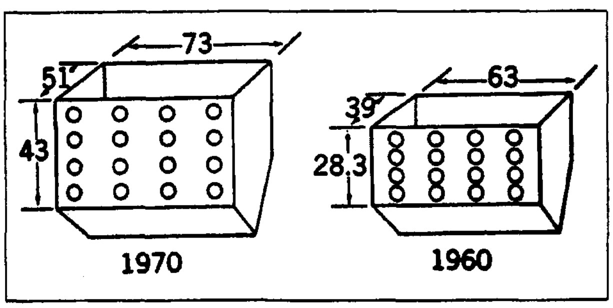

Fig. 31 Furnace design

FUTURE

We expect Power Generation during the 1980's & 90's to draw at least 50% of its expansion needs from Fossil Fuels. It is anticipated that more restrictive emission limitations will be imposed and that fuel quality will continue to deteriorate.

To obtain even lower NOx emissions, utilizing cost effective combustion modifications, it someday will be necessary to go to two (2) stage pulverized coal combustion with lower stoichiometries than presently applied commercially.

There is concern within the Industry when two-stage concepts are applied to pulverized coal containing high iron and sulfur (2%) in the ash. That concern is based upon many years of witnessing uncontrolled furnace corrosion resulting from localized reducing atmospheres. Thus, coals with high iron and sulfur are not, in our opinion, suitable for classical two-stage combustion in that the secondary furnace is subjected to reducing conditions and subsequent potential corrosion. Our concept is to isolate the reducing zone in a small controlled primary furnace that can either: a) be separately cooled to maintain low metal temperatures and thereby minimize corrosion, b) be made of more expensive exotic material that is corrosion resistant, or c) design the primary furnace

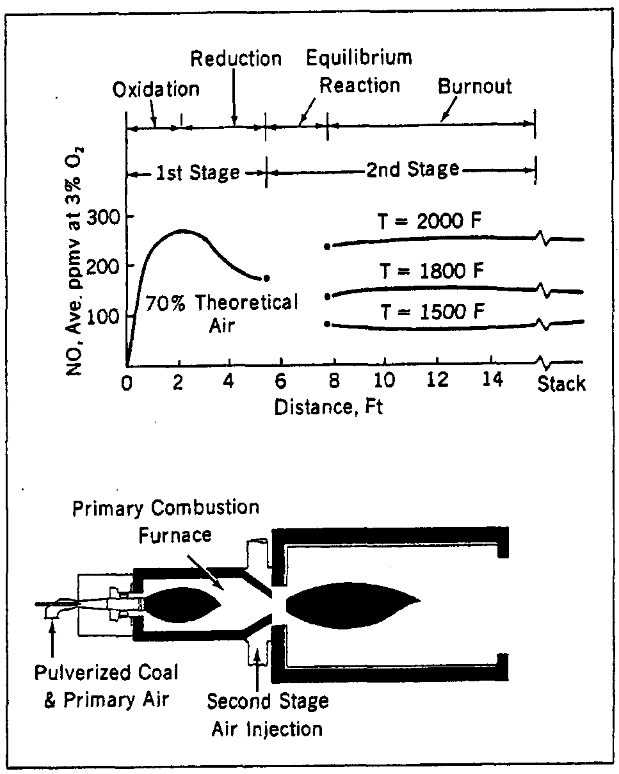

Fig. 32 Experimental low NOx combuster

to be expendable and plan to replace it after a period of years.

The B&W Low NOx Combustor is the development of that concept and has been demonstrated on a 4 x 10^6 Btu input scale. Fig. 32 illustrates the test facility with data presented for one stoichiometry in the two different combustion stages. The second stage NO exhibited a temperature dependence uncovered by S. Johnson that surprised us. Ongoing 50 x 10^6 Btu input Low NOx Combustor development (under the joint financial support of EPRI) will determine the commercial applicability of this concept.

Applying the low NOx combustor concept and lower grade fuel trend to a steam generator designed for 1990 service might result in a generator looking like this: (Fig. 33)

1. Tower design - lower quality fuels with higher ash loadings requiring minimum turns and ever increasing clear side spacing for falling ash deposits.
2. Low NOx combustor added as an auxiliary furnace to contain corrosion and obtain lower NOx emissions.

SUMMARY

In summary, we do not create the market conditions but react to specifications generated by our clients. Developmental work must consistently progress to insure that we continue to create commercially available conservative designs to meet those customer-generated specifications within applicable laws and at a competitive price.

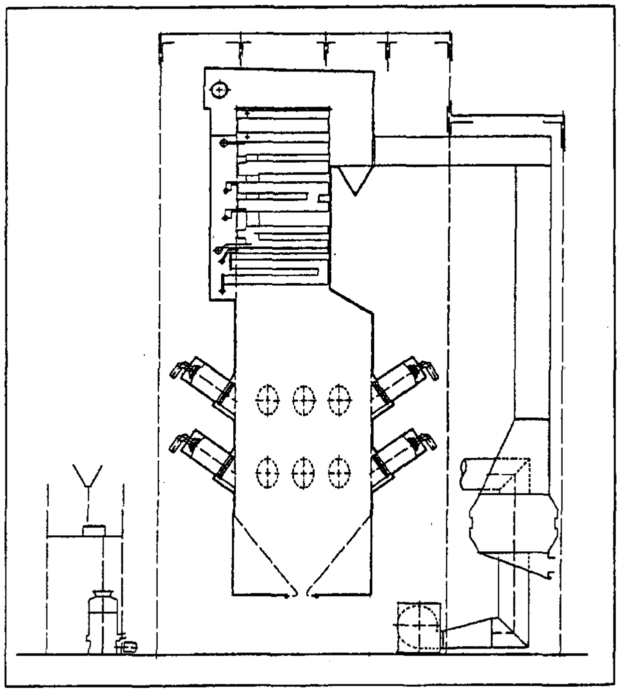

Fig. 33 Possible 1990 steam generator design

REFERENCES

1. Gray, R.J. and Moore, G.F., "Burning the Sub-Bituminous Coals of Montana and Wyoming in Large Utility Boilers", ASME paper 74-WA-Fu-1, Winter Meeting, November, 1974.
2. Ely, F.C. and Barnhart, D.H., "Coal Ash - Its Effect on Boiler Availability", Chemistry of Coal Utilization, Supplementary Volume, Lowry, H.H., ed, Wiley New York, London, 1963, pp. 280-891.
3. J.D. Blue, et al. "Effect of Coal and Multi Fuel Firing on Industrial Boiler Design", TAPPI Engineering Meeting, Seattle, Washington, October, 1974.
4. Attig, R.C. and Duzy, A.F., "Coal Ash Deposition Studies and Application to Boiler Design", American Power Conference Proceedings, 1969, pp. 290-300
5. Durrant, O.W., "Pulverized Coal - New Requirements and Challenges", 1975 ISA Power Instrumentation Symposium.
6. Haller, K.H., "Design of Large Coal Fired Steam Generators," November, 1976, Energy Systems Technical Sales Seminar (U.S. Dept. of Commerce) Dubrovnik, Yugoslavia, November 24, 1976.

7. Davis, C.M., Haller, K.H., and Wiener, M., "Large Utility Boilers, Experience and Design Trends," 1976 American Power Conference.
8. Moore, G.F., and Ehrler, R.F., "Western Coals-Laboratory Characterization and Field Evaluations of Cleaning Requirements", ASME Winter Meeting November, 1973.
9. Durrant O.W., "Design, Operation, Control and Modeling of Pulverized Coal Fired Boilers," Boiler - Turbine Modeling and Control Seminar, Sidney, Australia, 1977.
10. Heil, T.C., and Durrant, O.W., "Designing Boilers for Western Coal," Joint Power Generation Conference, 1978 Dallas, Texas.
11. Selker, A.P., "Overfire Air as a NOx Control Technique for Tangential Coal Fired Boilers", Environmental Protection Agency Symposium on Stationary Source Combustion, Atlanta, Georgia, 1975.
12. Johnson, S.A., Cioffi, P.L., and McElroy, M.W., "Development of an Advanced Combustion System to Minimize NOx Emissions From Coal Fired Boilers", presented at the Joint Power Generation Conference, Dallas, Texas, 1978.
13. Barsin, J.A. "Pulverized Coal Firing NOx Control", presented at the 2nd EPRI NOx Control Technology Seminar, Denver, Colorado, 1978.

BIBLIOGRAPHY

1. "Steam - Its Generation and Use", 38th Edition, Babcock & Wilcox, New York, New York.
2. Duzy, A.F., Rudd, A.H., "Steam Generation Design Considerations for Western Fuels", 1971 American Power Conference.
3. Duzy, A.F., Wagoner, C.L. "Burning Profiles for Solid Fuels", 1967 ASME Annual Meeting.
4. Brackett, C.E. Barsin, J.A., "The Dual Register Pulverized Coal Burner", 1976 EPRI NOx Control Technology Seminar.
5. Smith, V.L., "Coal Firing and Industrial Boiler Design - The Modern Approach", ASME 1975 Industrial Power Conference.

	SYSTEM ANALYSIS	FILE NO. 7645.41.010.22	
	ASH HANDLING SYSTEM	PAGE 13 OF 84	REV 0

TABLE 3-1. FUEL ANALYSIS-UNIT 4 AND 5 DESIGN BASIS COAL BLEND

	Design Basis Coal Blend Typical	Range
Proximate Analysis, per cent		
Moisture	18.5	4.0-32.0
Ash	7.9	4.4-15.4
Volatile Matter	31.0	24.6-32.1
Fixed Carbon	42.6	32.1-53.0
Ultimate Analysis, per cent		
Carbon	58.8	
Hydrogen	3.9	
Nitrogen	1.1	
Chlorine	0.03	
Sulfur	0.49	
Oxygen	7.9 9.28	
Heating Value, Btu per lb		
As received	10,285	7,700-13,000

Per M. Darcy 5/2/'01
From CR12 Dept

Also need design
Fly Ash HHV — High Avg 500, Low Avg 320 → 410 Btu/lb A.
Bottom Ash HHV — High 185, Low 70 → 150 Btu/lb A.

F-GN-189A

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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Experience with High Sodium Subbituminous Coals

J. A. Barsin
Product Manager,
Combustion Systems,
Fossil Power Generation Division,
The Babcock & Wilcox Company,
Barberton, Ohio
Mem. ASME

The Clean Air Act of 1971 limited sulfur dioxide emissions and thereby encouraged a tremendous increase in the use of low sulfur "compliance" coal. The individual states followed the Act with state implementation plans that encouraged existing steam generation plants to switch to low sulfur coals, which further increased the demand for low sulfur compliance coal. The steam generator designer learned much from these federal and state laws inducing compliance coal switchovers on steam generators not designed for those fuels. This presentation will describe some of the experiences we have had with high sodium, subbituminous coal retrofits. This experience provides the background that has led to the steam generator design which is being applied to these severe fouling fuels.

A great quantity of low sulfur, subbituminous coal exists in the Powder River region of Wyoming and in the Fort Union region of Montana. Many new mines have been opened since 1971; and in Montana alone, there are over 50 billion tons of known strippable reserves of subbituminous coals. The coal characteristics are typical of subbituminous coals: high in heating value, low in sulfur, good combustion characteristics, and a low (less than 10 percent) ash content. The ash has demonstrated typical lignitic behavior in our steam generators and the slagging and fouling characterisitcs of the mineral matter in these coals resemble those of a North Dakota lignite. This resemblance was not unexpected because the ash mineral matter is similar both in content and quantity. The second largest coal mine in the U.S., located in the Fort Union region, produces a subbituminous coal that has been widely applied as a retrofit fuel because of its availability and desirable characteristics.

B&W has organized coal testing programs in both our Research Center and our clients' operating boilers. The tests were undertaken to quantify the fouling, slagging, and combustion characteristics of a new coal. Over a 30 year period, empirical guidelines have been identified, presented, and published in this and other forums.

Much is known about Eastern U.S. bituminous coals because they have been extensively utilized for the past 150 years for steam production. Based upon the ash makeup and relative distribution of constituents, empirical indices which predict slagging and fouling potentials have been established and verified. The application of those indices influence our steam generator designs. Heat content and grindability determine the number and type of pulverizers required. The burning profile indicates the relative stability and residence time required for that fuel, which decides the type of combustor and furnace configuration. Moisture content determines the required drying primary air temperatures, and the fuel nitrogen now influences furnace sizing, combustion system selected, and excess air control requirements [1].

What is bituminous coal? We have defined it from the ash characteristic rather than strictly from the ultimate or proximate analyses. Bituminous ash, by our definition, exists when the ratio of iron (Fe_2O_3) to the sum of calcium (CaO) and magnesium (MgO) in the ash is less than one.

The pertinent slagging and fouling indices are based upon the base-to-acid ratio of the ash constituents modified by the sulfur content in the slagging case and by the Na_2O content in the fouling situation. The levels defined as high or severe are based upon experience gained over the past 100 years and are progressively refined. We might be unpleasantly surprised by a new bituminous ash, but the probability is low.

The applicable slagging index level that is utilized directly affects the plan-area maximum permissible heat release in the furnace; or stated more directly, the furnace size, number of furnace-mounted sootblowers, and allowable minimum side spacing of furnace platens. The fouling index applied affects the clear side spacing in the convection pass, maximum allowable furnace exit gas temperatures, and the number and location of sootblowers.

Our experience with subbituminous fuels is extensive, but not as complete as with bituminous. The lower heating value will require more pounds per hour throughput, and when coupled with the lower grindability, will require a greater number of pulverizers than an equivalent electrical output bituminous-fired steam generator. The higher inherent moistures require hotter primary air (drying) temperatures and will result in suppressed flame temperatures that reduce spot furnace absorptions, and reduce ignition stability during low load and cold start-ups. This reduction in potential ignition stability is somewhat offset by the normally higher volatility contents. The higher primary air temperatures do require hotter flue gases to the air heater, which affects the steam generator's internal heat balance.

Lignite-type ash, a term which covers most of the subbituminous and lignite fuels in the U.S., has been defined by us to exist when the Fe_2O_3 to MgO - CaO ratio is greater than one. Several slagging indices have been developed to explain observed phenomena and are based upon the measured fluid temperature of the slag. If the slag is wet (fluid), it can be moved about by sootblowers, but not removed. If slag is allowed to

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temperatures rise and the slagging area is forced higher into the furnace. This process can increase deposit temperatures further downstream, which increases deposit hardness. The flow properties of slag at various viscosities were studied in the fluid, plastic, and solid ranges. Those studies have resulted in the T_{250} and $T_{10,000}$ relationships published previously [2]. The wall must, by design, be kept as far away as possible from slag existing at temperatures corresponding to the 250 to 10,000 poise level. The slagging index bases can use fusion temperatures or actual measured viscosities produced from laboratory ash. The effect upon furnace size from the index selected can be drastic.

The potential for tube bank ash fouling is related to the vaporized ash constituents (mainly the compounds of sodium) which condense in the cooler zones of the convection gas passes. Fuels with lignitic ash have demonstrated fouling potentials directly related to the Na_2O levels in the coal ash. These levels have been indexed, and at a 6 percent Na_2O level and above, North Dakota lignites are considered severe fouling [3]. The boiler designer, as in the bituminous case, is forced to decrease furnace exit gas temperatures, increase the number of sootblowers, increase the clear side spacing, and relocate tube metal surfaces to have the coldest metal in the highest gas temperature zone as the percent of Na_2O increases. Bituminous ash deposits increase in strength with time and become more difficult to remove. Lignitic ash deposit strength does not vary with in situ time.

In a new boiler design, the coal source and the range of coal ash analyses for the potential design fuels must be established before the design and sizing of boiler and fuel equipment is initiated. A boiler designed for specific coals can usually operate efficiently with a similar coal, but it is exceedingly difficult to change to a coal with more severe slagging and/or severe fouling potential. The suitability of a new coal source applied to an existing boiler can be determined by an examination of the slagging and fouling indices of the new coal ash. If one design criterion had to be singled out as the most important, adequate furnace sizing would be our nominee. There is no practical way to enlarge a furnace after the unit is built. If the furnace is not large enough, wing walls or platen surface can be added (usually at great expense) to lower the furnace exit gas temperatures. The next major consideration is the convection pass design with respect to the ash fouling potential. If the flue gas temperatures are too high, tube side spacing too compact, tube bank depth too great, tube metal temperatures too high, and/or the gas velocity too high, the result will be severe deposition removal problems and erosion. Solutions are possible and range in complexity from partial derating to surface readjustment; but they are expensive in terms of required downtime and installation costs. The quantity of ash, while important from a mass handling and velocity-related erosion potential viewpoint, does not directly affect the slagging and fouling potentials of the coals. The ash quantity is a prime factor in the length of time it will take to be confronted with operating problems related to the ash analysis.

The majority of the experience to date on firing the Montana-Wyoming coals classified as severe slagging and severe fouling has been with existing units or "retrofits."

RETROFITS

In the specific case of a conversion from the design base bituminous coal, which had been utilized for the operating life of the steam generator, to a subbituminous "compliance" coal, the introduction indicates the importance of the ash characteristics to fouling and slagging. The problems associated with coal grindability, moisture, and ash loading influence the pulverizer plant capacity, and thereby the unit capability. The additional gas weights, because of the higher moistures and higher mass flow throughputs in the steam generator, affect the thermodynamic absorption balances of the furnace, superheater, and reheater; increase sootblower requirements in the furnace and convection pass; increase the potential for gas-side erosion; and require larger electrostatic precipitators to meet particulate standards.

The opportunity to quickly learn more about these fuels by verifying our laboratory index classifications encouraged us to participate in various retrofits. Several B&W units designed for bituminous coal were tested, firing medium to high sodium subbituminous coals. The units ranged in size from 156 MW to 1300 MW and the combustion system utilized in the initial design included both pulverized coal and cyclone furnaces. The Na_2O contents in the coal ash ranged from 3 to 9 percent.

The most comprehensive early retrofit test firing occurred at Detroit Edison's St. Clair Plant. The early total plant experience has been reported previously [4]. This presentation will concentrate on the experience gained from one of the four B&W 156 MW units in service at that station, briefly review other retrofit experiences on older designed units, and review a test burn on a unit designed for medium sodium subbituminous fuel.

St. Clair Unit 4

Unit 4 at St. Clair is a 156 MW (1,070,000 lb/hr steam) 1000 F/ 1000 F steam generator designed in 1951 for Eastern bituminous coal. Five E-70 pulverizers were supplied, initially based on a 55 Hardgrove grindability with 70 percent passing through 200 US screen, coupled to 16 circular burners. Unit 1 was placed in service in 1953, followed progressively by Units 2, 3, and 4 in October, 1954; all units are duplicates of each other. Detroit Edison was successful in operating these units at 175 MW (1,230,000 lb/hr steam) or 120 percent of rated design in continuous service on the design or similar fuels. The initial complement of sootblowers (18 convection pass retractables and 16 furnace wallblowers), with air used as the blowing medium, were adequate for the design fuel. The initial test burn was to determine maximum continuous rating (MCR), precipitator performance, and potential fouling problems and commenced on August 5, 1973, for Unit 4. The test fuel, a subbituminous coal supplied from the Decker mine, had sodium ranging up to 9 percent with measured actuals between 5 and 8 percent. The load averaged 137 MW to check combustion stability, furnace conditions, attemperation capacity, and stack appearance. Conclusions from that one day test indicated that stack appearances and attemperation capacity were acceptable, but the furnace was full of sparklers and combustion could have been improved. The second test burn commenced on August 20, 1973, and was aborted Monday, August 27, by switching to the base bituminous fuel. Our objectives during this one week test were to check and adjust pulverizer fineness, check mill capacity and power requirements, observe slagging and fouling, and obtain operating and performance data, including HVT gas temperature readings.

Observation indicated that slagging was occurring, but controllable. Fouling was a major problem and pulverizer capacity/fineness had to be adjusted.

The third test burn commenced September 18 and was terminated on October 3, 1973. During the initial five days, the unit was loaded at 156 MW during the day and reduced each night to 80 MW for five hours to deslag. A suspected tube leak forced a shutdown on Saturday, September 22; and while down, severe fouling was observed in the third pendant secondary superheater (2 in. clear side spacing). The unit was returned to service, and was held to 110 MW during the day and 60 MW at night. Shutdown on the next Friday indicated severe pluggage and the unit was washed with high-pressure water to allow MCR performance on October 1 and 2. On October 3, the unit was returned to base bituminous coal, and on October 4, baseline normal coal performance was obtained.

Observations — Third Test Burn. (See Figure 1.)

1. Sootblowers. The sootblower blowing medium was not adequate. Sootblower coverage was also inadequate as spaces between blowers were plugged with deposits. Furnace walls remained relatively clean where blowers were located. Deposits occurred where blowers were absent.
2. Pulverizers. The mill outlet temperatures dropped to 130 F with no problem and resulted in reduction of pyrite box fires. An MCR of 156 MW was obtained with all 5 mills in service, but no margin was available.

		Deposit 3rd BK SSH	Samples 3rd BK SSH
Moisture	21.1		
Volatile	40		
Fixed carbon	52		
Ash	7.0		
Sulfur			
Btu/lb	9576		
C	79.4		
H	4.2		
N	1.3		
O	8.0		
Sul	0.7		
Ash	6.4		
Fe_2O_3	9.5	9	11
Al_2O_3	18	19	17
SiO_2	33	24.4	28.3
TiO_2	0.6	1.1	1.0
MgO	3	6	6
CaO	9	22	19
Na_2O	4.8	5.4	5.3
K_2O	0.8	0.5	0.6
SO_3	17.4	14.6	10.2

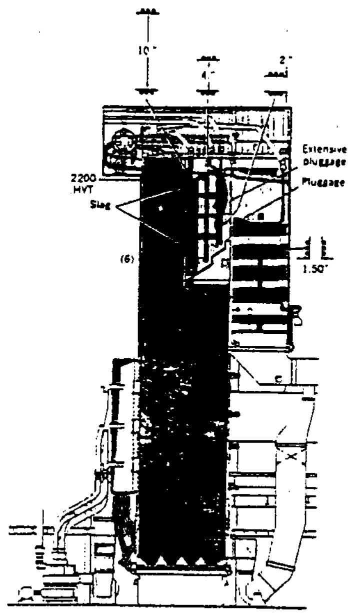

Figure 1 St. Clair Unit 4 after second test burn with high sodium subbituminous coal

3. Slagging. The upper furnace in the arch area, where no furnace wall sootblowers were located, exhibited slagging.
4. Fouling. In the third pendant secondary superheater, heavy deposition occurred over the upper 75 percent of the section. Hard deposits were found on tubes with soft deposit in lanes between tubes. In the horizontal reheater, pluggage extended 4 ft from the front towards the rear.

Based upon the test burns, we recommended to Detroit Edison that:

1. Pulverizers be upgraded from E-70 to EL-70 to gain capacity and the primary air fans be upgraded to gain capacity.
2. Sootblowers be increased to provide coverage where there was none. Clear side spacing as a function of gas temperatures exceeded our 1973 standards for the test fuel, but resurfacing was not considered.
3. Attemperator capacity in the superheater be increased to obtain more spray flow capacity.
4. Unit will exceed our velocity limits for gas side erosion at the 156 MW MCR.
5. Units not be operated above 136 MW (940,000 lb/hr of steam) when firing the test fuel because of the severe erosion potential and the lack of clear side spacing as related to fouling potential.

Conclusions. The clear side spacing as a function of design gas temperatures HVT (circa 1952) indicated to us that the unit would have serious fouling problems in the third pendant secondary superheater and horizontal reheater. The observed performance confirmed our expectations. Pulverizer capacity was marginal, sootblowers and blowing medium were inadequate, and the superheater was over-surfaced.

By September, 1976, the pulverizers had been uprated and the additional sootblowers were installed. Operation was possible at 156 MW for a maximum of three weeks before being forced to shut down because of third pendant secondary superheater and horizontal reheater pluggage. The plant was visited in April, 1977, and was burning an approximate blend of 25 percent Eastern bituminous and 75 percent subbituminous high sodium coal. Continuous loads of 170 MW could be maintained for several days with the increased blowers, increased blowing medium, and blended fuel. The furnace walls were lightly slag-covered and the flames were observed to be impinging on the rear wall and sidewalls.

Presently (1980), the maximum load on subbituminous high sodium coal only is limited by pulverizers to 135 MW. The combination of oil and subbituminous coal permits a 160 MW MCR for peaking purposes. Studies are in progress to add to or further upgrade the existing pulverizers, add burners to reduce the per burner heat input, and review the removal of secondary superheater surface.

Tanners Creek Unit 3

Indiana and Michigan Electric Company test-fired high sodium subbituminous coal on Tanners Creek Unit 3 on August 8, 1973. Unit 3 is a B&W 210 MW (1,335,000 lb/hr steam), 1050/1050 F, 2075 psig steam generator equipped with seven E-70 pulverizers coupled to 16 multitip down shot burners (Figure 2). Initially, 16 retractable sootblowers and one furnace blower were furnished for this unit designed in 1950 for Western Kentucky bituminous coal.

Fuel analysis	River Queen mine normal	Decker mine test fuel
Moisture	8.8	25.6
Volatile	34.1	41
Fixed carbon	38.1	53.8
Ash	27.8	5.2
Sulfur	7.4	0.5
Btu Dry	10,090	12,490

Ash analysis	River Queen mine normal	Decker mine test fuel	Reheater Deposit (Decker)
SiO_2	43	29.4	26.7
Al_2O_3	18	20	22.5
Fe_2O_3	31	8	10.0
TiO_2	0.7	0.6	0.9
CaO	2.9	13	19
MgO	1.1	3.5	5.5
Na_2O	0.4	6.1	5.3
K_2O	3.1	0.8	0.7
SO_3		16.8	10.2
T_{250}	2210	2100	
T_{FT} (red)	1940	2050	
T_{Fluid}	2280	2260	

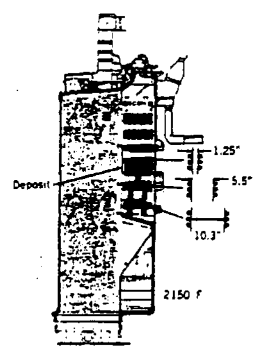

Figure 2 Tanners Creek Unit 3 after test with high sodium subbituminous coal at 1200 MW maximum load limit

On August 8, the unit was switched directly from River Queen Coal, Western Kentucky, to a high sodium subbituminous coal. No attempt was made to remove the deposition caused by the River Queen Coal. The unit was operated at approximately 170 to 180 MW during the test. After 1½ to 2 days, a large deposit was found forming in the reheater just above the first primary superheater. The gas passage in the reheater (1½ in. clear side spacing) was plugged solid on August 10 and the unit had to be shut down. The deposit in the reheater was removed with difficulty and the superheater was water-washed so that most of the deposition was removed.

The unit was restarted and brought to 110 MW on August 16 and held at that load during the test. The unit started to plug again on August 18 in the same location as before. It was decided to revert to River Queen Coal and terminate the test coal in Unit 3. On August 19 the unit was taken out of service because the reheater had plugged again.

The fuel, ash, and deposit analysis indicated that 6.1 percent Na_2O coal was being burned and that the rapid reheater pluggage was not surprising due to the lack of clear side spacing, tube metal temperatures, sootblower coverage, and fouling characteristics of the test fuel.

Conclusions. This unit was not capable of burning a high sodium subbituminous fuel.

Amos Plant Unit 3

Appalachian Power Company's John E. Amos Plant, Unit 3, is a B&W supercritical steam generator rated at 1300 MW (9,755,000 lb/hr steam) at 3645 psig and 1010/1000 F. Initial equipment included 12 MPS-89 pulverizers supplying 48 two-nozzle cell burners horizontally opposed, 103 furnace wall sootblowers, 24 convection pass retractable blowers with steam as blowing medium, and wing walls in the upper furnace. The unit was designed in 1969 for severe slagging, high fouling bituminous coals, and is the largest steam generator in the free world from both a physical and electrical standpoint. The unit was placed in commercial operation in October, 1973, and test fired high sodium subbituminous coal in April, 1974. The test firing objective was to observe the effect of this severe slagging and fouling fuel on the unit.

At the time of the test, the unit was operating at load demand with an upper load limit of 1200 MW (out of 1300 MCR) due to an out-of-service air heater. West Virginia coal was being burned with no visable furnace slagging. Secondary superheater slagging was limited to a dry brittle ash that had formed fins 3 to 4 inches long at the bottom of the leading tubes of the secondary superheater. Retractables were blown once per day and controlled these deposits. The high sodium (5.9 to 7.2 percent) subbituminous coal was supplied to all mills on April 15, 1974, with the unit at 850 MW. Unit load was slowly raised over a two-day period to 1210 MW by varying the load limiting factors such as primary air fan amperage (one tri-sector air heater out with hot primary air system), reheater outlet temperature (high), boiler gas outlet temperature (high), and the two in-service air heater pressure drops. The twelve pulverizers had to be in service, mill outlet temperatures were reduced to unload the primary air fans, overall excess air was lowered from 20 to 18 percent to reduce exit gas temperatures, and gas recirculation fans were reduced in loading — all to obtain the maximum possible load of 1210 MW. Air heater ΔP and primary air fans proved the limiting factors.

On April 21, load was reduced (5 days at 1200 MW, 92 percent MCR) because of high boiler exit gas temperatures and high reheat temperatures. Load was gradually reduced over the next 2½ days from 1200 MW to 1060 MW when a forced outage (loss of packing on a heat pressure heater valve) occurred.

The following observations were made (Figure 3):

1. Combustion. Fires were stable with 135 F mill outlet temperatures: coal fineness was 69 percent passing through a 200 mesh, 99 percent or more passing through 50 mesh.
2. Slagging. Furnace walls were coated with slag wherever no wall blowers existed. Upper furnace walls were plastic and running at times. The first pendant of secondary superheater lower section was occasionally running wet, while the upper portion remained dry. An internal inspection made during the forced outage indicated that extensive bridging had occurred below the steam-cooled spacer (16¼ in. clear lane side spacing). The crotch formed by the wing wall/rear furnace wall junction caught slag, and the surface was coated with slag 6 to 8 in. thick.
3. Fouling. The second pendant of the secondary superheater (7¼ in. clear side spacing) developed fins of 12 to 16 in. in length, which remained dry during the test duration. Sootblowers would have removed the deposits if they had been installed in the cavity. The horizontal reheater and primary superheater showed the start of pluggage similar to that observed at St. Clair (2½ in. clear side spacing).
4. Sootblowers. The furnace blowers controlled the slag in the areas covered. Additional blowers would be required in the upper furnace.

Fuel analysis

Moisture	25.4
Volatile	39.2
Fixed carbon	54.5
Ash	6.3
Sulfur	0.5
Btu/lb	12,470

Ash analysis

		Reheater Deposit
SiO_2	25	34.9
Al_2O_3	19	23
Fe_2O_3	7.0	9
TiO_2	0.9	1.0
CaO	15	17
MgO	2.5	4.0
Na_2O	8.6	6.03
K_2O	0.6	0.91
SO_3	20.4	4.0
T_{250}		
T_{FT} (red)	1990	
T_{FR}	2350	

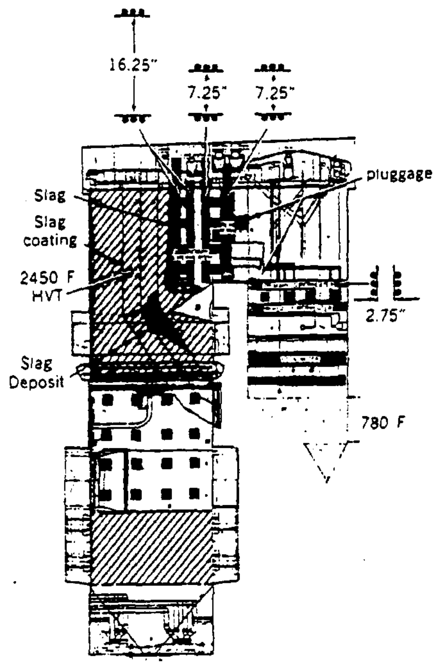

Figure 3 Amos Plant Unit 3 after testing with high sodium subbituminous coal

The addition of retractables to the zone in front of the secondary superheater would have aided deposit removal, but eventually the unit would have bridged over in that location unless water blowers were utilized.

If the reheater sootblowers were operated, boiler outlet temperatures would rise. If the blowers were not operated, the reverse was true. The dilemma of not being able to manipulate sootblowers to control both reheat temperatures and final boiler exit temperatures was indicative of a sootblower control restriction which was to reoccur in latter test burns.

5. Reheater absorption increased (spray quantities to maximum by the second day of testing) and secondary superheater absorption decreased (due to slag deposition), while load and excess air were held constant. The reheater absorption was 11 percent higher while firing the high sodium subbituminous coal at 1200 MW than it was firing the design coal at 1300 MW.

Conclusions. The unit is not capable of burning the high sodium subbituminous coals at high loads for an extended period of time without modifications. Furnace exit gas temperatures were calculated from the heat balances and indicated that 2450 F HVT was obtained on the test coal after five days of firing at 1200 MW. This level grossly exceeded both the design level (at 1300 MW) and the tentative standards proposed for high sodium fuels with lignitic type ash.

Powerton Unit 52

Commonwealth Edison had test fired and converted many units in their system to high sodium subbituminous fuels by 1975. In April, 1975, the company decided to test fire this coal on Unit 52 at Powerton Station to determine if the fuel could be burned effectively in that unit; and if derating were required, how great would it be and what changes in operational procedures would be necessary. Unit 52 is a B&W once-through steam generator rated at 430 MW (3,036,900 lb/hr steam) at 1000/1000 F and 2400 psig. Initial equipment included 10 horizontally opposed cyclone furnaces, 66 furnace wall sootblowers, 82 convection pass retractable sootblowers using steam as the blowing medium, and no wing or division walls in the furnace. The unit was designed in 1969 for severe slagging, severe fouling Illinois coal from Peabody's Mine 11. It was placed into operation during April, 1972, burning a fuel similar to the design coal and operated as half of a duplicate set of boilers feeding one 850 MW steam turbine.

The design maximum steam flow could not be obtained due to both the coal feeder and the induced draft fans at maximum loadings. The actual flow obtained was 2,800,000 lb/hr steam or 92 percent of MCR. Observations from firing 44,700 tons of high sodium coal indicated that: carbon carryover from the cyclones increased, furnace slagging increased but was controllable, the reheat temperatures increased, and the boiler outlet gas temperatures increased. Reheat steam temperatures were controllable by increasing reheat flow (biasing reheater flow to the twin unit) and increasing attemperator flow.

Conclusions. The high sodium subbituminous could be burned successfully at Powerton. Improvement in cyclone operation and a reduction in gas weights, possibly by mine drying of the coal to reduce reheater absorption and transportation costs, should be tried.

The dried coal burn test commenced September 15, 1975, with approximately 30,000 tons dried to 16.7 percent (23.5 percent raw). The dusting problems associated with handling the dried coal forced the use of water sprays which increased the moisture to 21.6 percent. However, with the partly dried coal, a 100 percent MCR of 3,036,900 lb/hr steam flow was obtained, the carbon loss decreased slightly, and the reheat attemperator flow was reduced.

Observations. (See Figure 4.)

1. Combustion. The low ash fusion temperatures contributed to good taping, but when combined with the different burning characteristics of this fuel in a cyclone furnace, added to the high unburnt carbon carryover. The base Illinois coal exhibited about a 2 to 4 percent unburnt carbon residue in the fly ash but the subbituminous coals ranged from about 11 percent for the dried to 14 to 17 percent for the raw as-mined coal.

Fuel analysis

	Dried	Raw
Moisture	20.5	23
Volatile	41.7	
Fixed carbon	52.3	
Ash	6.0	4.2
Sulfur	.7	.4
Btu/lb	9782	9610

Ash analysis

		Deposit Furnace	Deposit SSH
S_iO_2	27.6	10.5	37.1
Al_2O_3	13	16.4	23
Fe_2O_3	12	10.0	11
T_iO_2	0.6	(with Al_2)	0.8
CaO	15	17.9	14
MgO	3.0	3.04	3.5
Na_2O	5.11	10.92	7.54
K_2O	0.81	.96	0.82
SO_3	18.8	25	0.3
Carbon (%)	11-13	12-16	

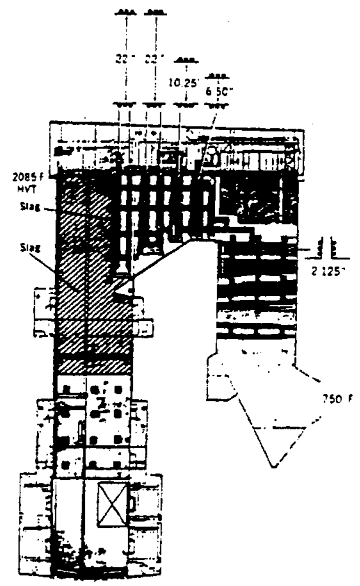

Figure 4 Powerton Unit 52 after testing with high sodium subbituminous coal

2. Slagging. Molten slag existed on all furnace walls just above the top row of furnace sootblowers. Fins on the first pendant of the secondary superheater (22 in. clear side spacing) were 6 to 12 in. long with the leading edge molten. Slag sodium levels were measured at 7.54 percent in these deposits, which indicates some enrichment was taking place. No bridging across the lanes or plugged backspacing was observed.
3. Fouling. Reheat deposits were 6 to 12 in. long, dry, and could have been removed by sootblowers if the reheater absorption would have permitted more frequent use of those blowers.

Conclusions drawn from the second Powerton dried tests reconfirmed that high sodium fuel could be burned in the unit successfully, but additional work on the combustion system would be required to reduce the unburnt carbon levels. Presently (1980), the unit has been converted to 100 percent subbituminous coal from the Black Butte Mine. The sodiums are variable and do include those considered "high" sodium. Carbon utilization has been improved but additional work is planned to obtain an acceptable level.

Several other test firings were conducted (i.e., Detroit Edison's Monroe Station and Commonwealth Edison's Will County involving B&W units), but the four units presented above are typical and served to verify our design classification of the high sodium subbituminous coals.

INITIAL DESIGN FOR SUBBITUMINOUS COAL

During mid-1973, we proposed to Houston Lighting & Power two units (Parish 5 and 6) rated at 675 MW each (4,745,000 lb/hr steam) at 1005/1005 F and 2620 psig. These units were designed to burn No. 6 oil, natural gas, and subbituminous coals that eventually (after initial design) ranged to 6 percent Na_2O as a coal source was finalized. The field test retrofits had not yet occurred and the unit was designed for severe fouling/severe slagging per our laboratory indexes. The units were sold and detail-engineered in 1974, and went into initial operation on gas during December, 1977. Initial equipment included seven MPS-89 pulverizers coupled to 56 Dual Register pulverized coal/natural gas and No. 6 oil low NO_x burners, a compartmented windbox, no wing walls or division walls in the furnace, 64 furnace wallblowers, and 72 convection pass retractable blowers located on 12 ft vertical centers with steam as the blowing medium.

B&W was greatly interested in field testing a unit designed to the new conservation of the 1971-72 period for a medium sodium subbituminous coal, thus determining the unit's adequacy for that fuel and the higher sodium levels commonly found in some subbituminous fuels. We approached Houston Lighting & Power in 1978, suggesting a joint cooperative test burn of medium to high sodium fuel in the B&W units at Parish Generating Station. Houston Lighting & Power, in 1978, contracted for a long-term supply of coal for use at the Parish Station, which would have sodium levels as high as 14 percent. In August, 1979, the Lower Colorado River Authority (Fayette Project) Unit 1 firing high sodium subbituminous coal experienced severe pluggage problems. This (7 percent Na_2O) experience alerted the operational management of Houston Lighting & Power that the coal purchased for units already constructed might prove to be troublesome. In September, 1979, they agreed to support a test burn of high sodium lignite at the Parish Station on our units.

B&W's test objective was to determine if a medium to high sodium oxide subbituminous coal could be burned in a unit designed to burn severe slagging/severe fouling coal. Additionally, if the unit was not capable of handling high sodium coals, what experiments could be included during the test burn to indicate future design changes which make and improve the flexibility to handle more severe high sodium fuels. The objective for Houston Lighting & Power was to uncover any limitations on a fuel similar to that purchased for units already designed, constructed, and operating.

Test Preparations

Additional extended lance sootblowers were installed on the left side in front of the secondary superheater and in front of the secondary superheater outlet to determine an effective blower cleaning radius. Additional furnace sootblowers (14) were installed above the gas tempering duct to aid in removing deposits noted on other units which did not have sootblowers located in that area. Additional observation doors (18) were installed in the secondary superheater and reheater area. Stainless steel tube sections were installed in the secondary superheater outlet and reheater outlet to test and reconfirm Big Stone (lignite) observations, and were connected with slag shedding ability. Split-ring alignment castings were placed on the left hand side of the secondary superheater in several locations to allow evaluation of slag buildup and compare buildup to that observed on the wraparound tubes. See Figure 5 for the location of the changes made to the boiler prior to the test.

Fuel

The coal burnt during this test was from the West Decker Mine near Decker, Montana, with 300,000 tons available for the test period. The unit train contained an average sodium content in the ash at 7.53 percent, base to acid ratio of 0.98, as-received ash content at 3.83 percent, and moisture at 23.82 percent. These analyses from the trains were furnished by Peter Kiewit & Sons of Omaha, Nebraska.

Tests

According to our design calculations, a steam flow of 4,100,000 lb/hr would produce 2025 HVT furnace exit gas temperature entering the 24 in. secondary superheater side spacing. Observations and evaluations were made at this furnace exit gas temperature loading level and once evaluations were completed,

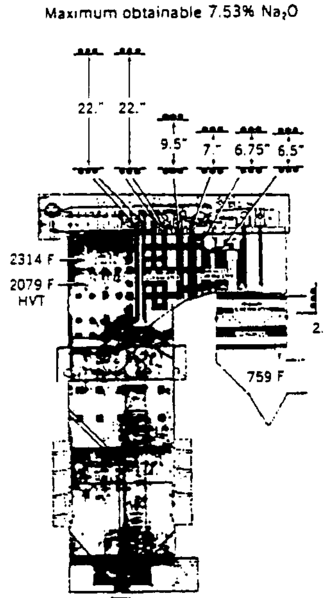

Figure 5 Parish Unit 5 after testing with high sodium subbituminous coal

the furnace exit gas temperature was increased to full turbine load or stack opacity limitations, whichever occurred first. The test commenced on November 17, 1979, carrying approximately 600 MW, which was carried constantly until November 26 when load was intentionally dropped to 400 MW overnight. The drop was an attempt to reduce the high economizer outlet gas temperatures going to the hot electrostatic precipitator and adversely affecting opacity.

During the test the sootblower control panel system design was found inadequate to allow the convection pass reheater and superheater surfaces to be blown as often as required and at the same time permit blowing the primary superheater and economizer as required to maintain gas temperature levels acceptable to the hot electrostatic precipitator. If the gas temperature levels to the precipitator were maintained, fouling in the secondary superheater would occur. If the deposition in the secondary superheater was controlled, the economizer gas outlet temperature would increase because of the decrease in surface effectiveness in the primary superheater and economizer. This problem was a repeat of the Amos Unit 3 limitation (Figure 6).

On November 29, load was raised to 4,700,000 lb/hr steam (approximately 700 MW) and held for several hours. It was dropped to 100 MW briefly to shed slag, and then raised to 700 MW for several more hours. We jointly evaluated that the boiler could not continue operation at the 700 MW level. The reasons were associated with:

- Economizer outlet back end temperatures exceeding limitations
- Large deposits in the secondary superheater somewhat related to the failures in the sootblower control system, but primarily due to the fouling characteristic of the ash
- Difficulty in opening the bottom ash sluice tank gates

Observations

Sootblowers on the left side of the pendant convection pass, which were on 6 ft vertical centers, kept that entrance to the secondary superheater clean. Stainless steel tubes and alignment castings we installed collected little deposition which was easily removable. Installed sootblowers on both 12 ft vertical centers

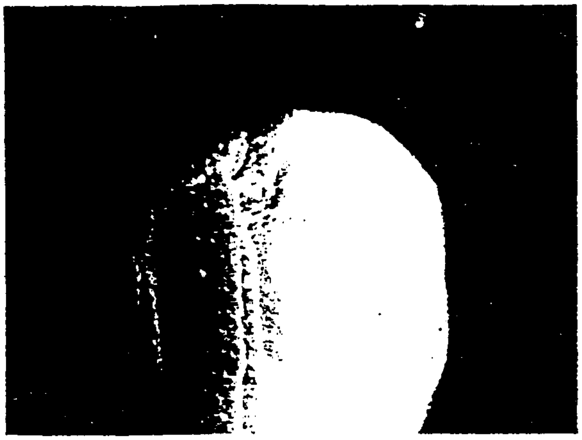

Figure 6 Secondary superheater inlet at MCR showing deposit on tubes and wraparound

and 6 ft vertical centers were effective in controlling deposits most times, but an effective cleaning radius of 4 ft in the high gas temperature zones with this ash was determined. The water blower was effective for bare metal cleaning under all conditions of operation. Primary superheater and economizer superheater tube deposits were removable by sootblower operation. The absorption of the secondary superheater, reheater, and primary superheater varied greatly during the test series indicating radical changes in surface cleanliness, due primarily to sootblowing (Figure 7).

Figure 7 Secondary superheater inlet at 90 percent MCR showing deposit on tubes manually knocked off tube row closest to side wall

HVT temperature probe readings were obtained and compared to previously calculated HVT temperatures. At 106 percent of MCR the actual (back calculated) FEGT was 2312 F while the probe indicated 2314 F. Data at 89 percent MCR back calculated 2167 F compared to the probe reading of 2225 F. These temperatures were measured while entering the 22 in. clear side spacing, first steam-cooled surface after eleven days of testing.

Furnace slagging occurred in the upper furnace on both the left- and right-hand sidewalls above the highest level of furnace sootblowers. Deposits were dry and sootblowers could have cleaned the area if they had been located there (Figure 8).

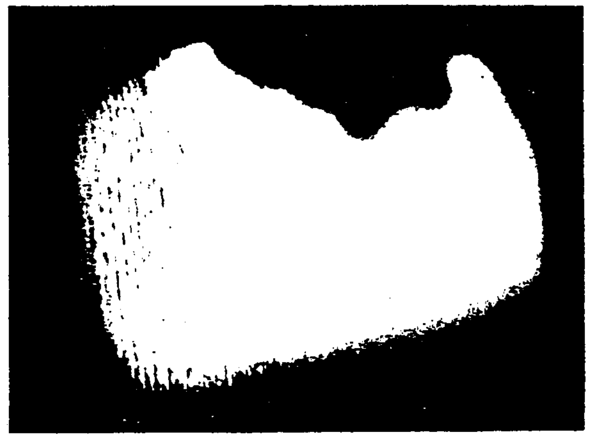

Figure 8 Left side wall showing upper furnace wall slagging at 100 percent MCR

The sootblower cycle required approximately 11 hours with only one (IK) long retractable sootblower level on each side of the boiler operating at one time. Sequence associated with the (IR) furnace sootblowers required that full retraction occur prior to the second IR blower advance. System measurements indicated that supply lines probably experienced high pressure drop which inhibited the steam cleaning medium quantity. This problem, when coupled with the limitations of the control system itself, severely restricted the flexibility required to operate the sootblowers as desired.

The straight high sodium coal, coupled with the high gas temperatures entering the hot electrostatic precipitator, resulted in collection efficiency reduction and opacity complaints.

Conclusions

We conclude that the unit as presently designed is not capable of operating continuously at MCR while burning the coal, containing up to 14 percent sodium in the ash/coal, purchased by Houston Lighting & Power from Decker. Burning an average 7.53 percent Na_2O at 87 percent of MCR for continuous long-term periods is possible with the existing design. The maximum load test was aborted and the unit was cleaned up with a blend of Decker coal and Jacobs Range (Powder River, Wyoming) coal on an approximate 50/50 basis. Loading was held to 650 MW and cleanup progressed with the economizer outlet temperature and opacity limiting the load.

We have suggested to Houston Lighting & Power minor modifications in the areas of sootblower addition, sootblower control system flexibility, and minor pressure part changes, which could be instituted to allow the burning of a wider range of fuel with more severe fouling characteristics than has been possible to date.

One important conclusion is that a 50/50 blend of high sodium subbituminous coal and the Jacobs Ranch coals could be burned in the existing design at continuous MCR with no problems — and would result in improved performance of the electrostatic precipitator as an added benefit.

NEW DESIGN FOR HIGH SODIUM SUBBITUMINOUS COALS

In 1973, two units were proposed to Detroit Edison to burn high sodium subbituminous fuel. Each was rated at 666 MW (4,745,000 lb/hr steam) at 2665 psig and 1005/1005 F. B&W was awarded the contract for both units at the new Belle River Station in 1973, but because of slower load growth than anticipated, we were not released for engineering until 1977 (Figure 9). This time lapse was fortuitous as it allowed updating of the proposed design to reflect the high sodium subbituminous coal state of the art resulting from the various test

Fuel Analysis Specified

Moisture	23.1
Volatile	34
Fixed carbon	38
Ash	4.9
Sulfur	0.46
Btu/lb	9600

No Ash Analysis Provided Initially

$T_{FT\ (red)}$ = 2049

Design severe slagging
severe fouling

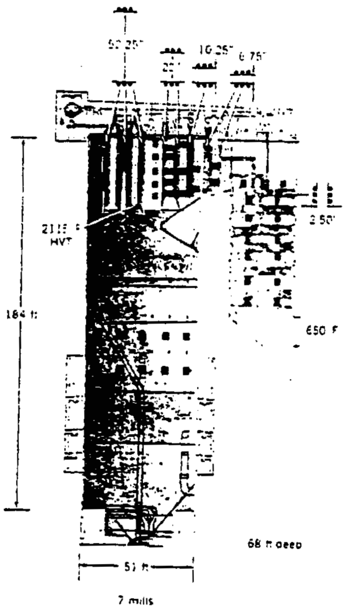

Figure 9 Belle River Units 1 and 2 as proposed in 1973

burns retrofits and additional laboratory work which had occurred in the interim. Detroit Edison Engineering and Operations input from the St. Clair, River Rouge, and Monroe test burns/retrofits, coupled with our test burn experience, encouraged the increased conservatism that has been incorporated into the detailed design of Belle River Units 1 and 2 (Figure 10).

Belle River has been designed for a severe slagging and severe fouling subbituminous fuel containing a range of sodiums up to 9 percent, which will be supplied from the Decker mine. The first unit is scheduled for initial start-up in 1983. Equipment includes 8 MPS-89 pulverizers, 56 Dual Register pulverized coal low NO_x burners, a compartmented windbox for excess air control, and 106 initial furnace sootblowers and 112 initial long retractable sootblowers.

The initial furnace wall sootblowers are arranged in a unique pattern, the Diamond Pattern, which is now B&W's standard for severe slagging rated coals. The pattern has been tested at Iowa Power Company's Council Bluffs Unit 3 (Bella Ayr Coal) and has been found extremely effective. The effective cleaning radius of the furnace blower is increased when applied to the relatively light, highly reflective slag deposits typical of subbituminous fuels. The convection pass long retractable blowers are on 7 and 8 ft vertical centers (3½ to 4 ft cleaning radius) in the high gas temperature 52 in. and 22 in. clear side spacing zones, and increasing to 3 ft vertical centers (1½ ft cleaning radius) in the lower gas temperature 6¾ in. clear side spacing zone (Figure 11).

The gas temperature entering the 22 in. clear side spacing steam-cooled surface has been designed at 2040 F HVT when the unit is firing the design fuel at the maximum continuous rating.

The wraparound tubes designed to hold the superheater pendants in alignment have been removed. Our experience with the Houston Test Burns and our long-term experience on North

1. Mills increased from 7 to 8.
2. Unit width increased from 68 to 82 ft.
3. Gas side velocities reduced to a maximum of 65 ft/sec.
4. Coal feeders changed from 24 to 36 in. diameter inlets.
5. Furnace sootblowers increased from 48 to 106 and rearranged in a diamond pattern. Retractable sootblowers increased from 64 to 112--decreasing required cleaning radius to 4 ft or less.
6. Average design furnace exit gas temperature 2115 F HVT reduced to 2040 F HVT entering the 22 in. clear side spacing.
7. Elimination of overfire air system.
8. Wraparound tubes eliminated.
9. Stainless steel used for pendant leading edge tubes.

Figure 10 Belle River design updates to increase conservatism and reflect 1971 state of the art

Average furnace exit gas temperature	2040 F HVT
Fuel analysis	
Moisture	24
Volatile	34
Fixed carbon	39
Ash	4
Sulfur	0.4
Btu/lb	9550
Ash analysis	
SiO_2	53.3
Fe_2O_3	8
Al_2O_3	16.5
TiO_2	0.9
CaO	11.5
MgO	2.0
SO_3	1.3
K_2O	1.0
Na_2O	8.0
$T_{FT\ (red)}$	2049

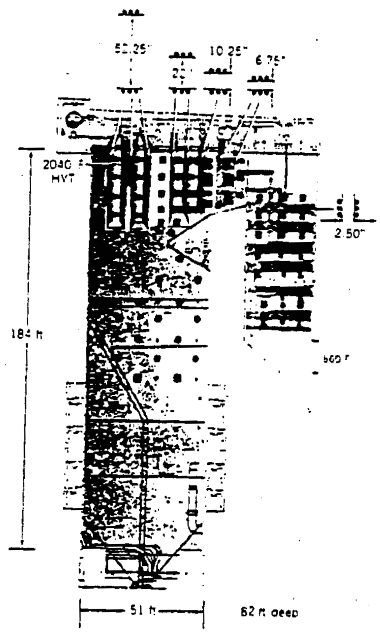

Figure 11 Belle River Units 1 and 2 as built

Dakota lignites indicated that these would act as slag catchers and sootblower erosion points when applied to a severe slagging/severe fouling fuel. The alignment of these elements continues to be necessary and will be accomplished by applying split ring castings which will greatly reduce projections into the gas lanes.

Experiments have indicated that deposit bonding strength to austenitic steels is much less than the bonding strength developed between a deposit and ferritic steels. On Belle River the leading edge tubes of the superheater and the reheater are fabricated from 304 stainless. This application will further improve deposit removability in the 10¼ in. and 6¾ in. clear side spacing zone.

SUMMARY

The majority of the experience in firing those Montana/Wyoming coals classified as severe slagging and severe fouling has been on existing units. The behavior of the ash in these tests has been related to new boiler designs to handle the severe slagging and severe fouling coals. One such new design is incorporated in Detroit Edison's Belle River Units 1 and 2. Based upon the experiences related in this presentation and previous work, B&W has been able to utilize the design factors necessary to provide a boiler capable of outstanding performance with a most severe slagging and severe fouling coal/ash.

ACKNOWLEDGEMENTS

The author thanks the Detroit Edison Company, Indiana and Michigan Electric Company, The American Electric Power Service Corporation, The Appalachian Power Company, the Commonwealth Edison Company, and the Houston Lighting & Power Company for their cooperative assistance during many of the activities reported herein. In addition, the work of our former fuels specialist, G. Fred Moore, and former field engineering specialists, M. E. Murphy on the Appalachian Electric Power Test Burn and R. E. Dean at the Houston Lighting & Power Test Burn, contributed greatly to the formulation of our present design standards and this presentation.

REFERENCES

1 Barsin, J.A., "Boiler Design Considerations," Coal Combustion Technology & Emission Control Conference, Pasadena, California, February, 1979.

2 Moore, G.F. and Gray, R., "Burning the Subbituminous Coals of Montana and Wyoming in Large Utility Boilers," 1974 WA/Fu-1-ASME.

3 Barsin, J.A., "Experience with High Sodium Lignites," University of New Castle, New South Wales, Australia.

4 Bilenchi, T., Yates, H., and Sinnott, R., "Experience with Decker Coal at Detroit Edison's St. Clair Power Plant," American Power Conference, April, 1975.

Technical Paper

Experience with high sodium lignites

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Fossil Power Generation Division
Barberton, Ohio

Presented to:
The University of Newcastle
New South Wales, Australia
August 28, 1979

BR-1143

Babcock & Wilcox

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Summary

Babcock & Wilcox's professional association with the lignites of North Dakota goes back in time about 30 years. Over that 30 year period of time we have learned much about designing for the slagging and fouling characteristics of that difficult fuel. For each new design generation, from stoker firing, and pulverized coal, to cyclone furnaces the most conservative designs were applied. The cycle pressures and temperatures were increased to reduce net plant heat rates, thus new designs and innovations had to be developed to deal with the slagging and fouling properties of that fuel.

This presentation will share with you some of the more recent experiences we have had with North Dakota lignites and the background that has led to the development of a new steam generator design that could be applied to these severe fouling fuels.

Introduction

Our association with the North Dakota lignites on utility steam generators larger than 100 megawatts, goes back to the early 1960's and for the purpose of this discussion is divided into three design generations i.e., units smaller than 100 megawatts which were pre-1960; units sized between 100 and 200 megawatts popular during the 1960-1970 era and units larger than 250 megawatts, which cover 1970 and onwards. During the design stages of each generation the most conservative design available at that time for the cycle condition specified was the basis of our offerings. The three design generations recognized the severe fouling potential of North Dakota lignites and each generation built upon the successes and failures preceding it.

It is well documented in the literature that sodium in North Dakota lignite is an indicator of that fuel's fouling potential. Gronhovd, et al 1969, established a deposition rate for North Dakota lignites with varying sodium contents. We modified that to obtain a fouling index which agrees with observed performance of utility boilers firing this fuel. Our observations indicated that not only was the rate of deposition related but the sintered strength of the deposit formed became greater as the sodium content increased. Fig. 1. The slagging characteristics of this fuel are predicted by the fusion temperatures of the coal ash. When the ash fusion temperatures are low the probability of slagging is great. A slagging index for North Dakota lignites was determined

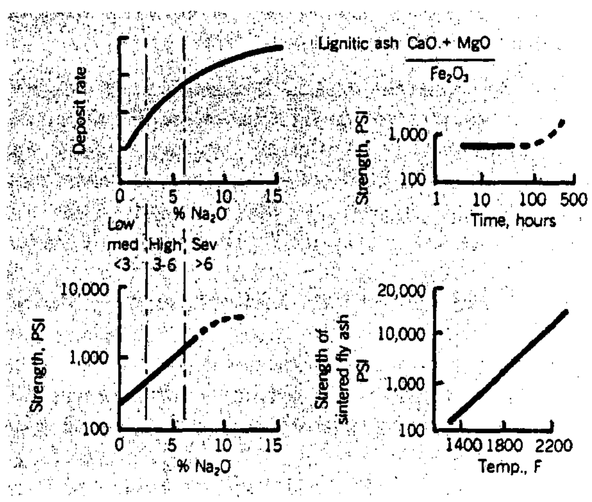


Fig. 1 The effect of sodium

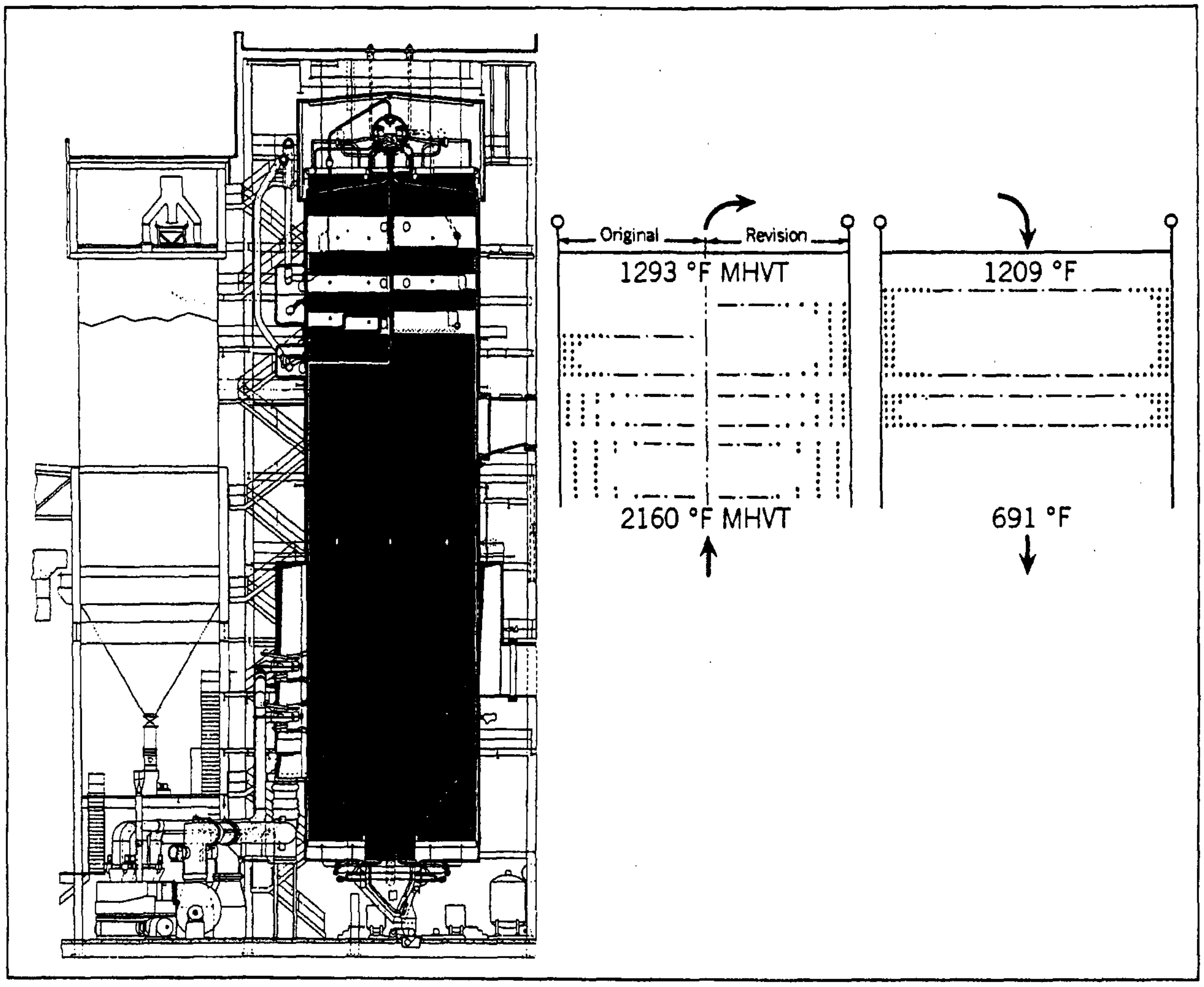


Fig. 2 High sodium lignite pulverized coal application

utilizing the fusion temperatures of the lignite ashes, and comparing those to observed slagging characteristics on the different design generations utilizing those fuels.

Our first generation utility design steam generator for North Dakota lignite was a 66 megawatt pulverized coal-fired steam generator rated for 695,000 lbs/hr at 1275 psig superheater outlet and a final steam temperature 955°F. The fuel utilized was Beulah North Dakota lignite; heating value of 6,200 Btu per pound; 35% moisture; and up to 14% sodium oxide in the ash. Initial operation during 1964-65 indicated the unit was adequately designed for sodium levels up to about 8% in the ash, but fouling in the primary superheater did take place at sodium levels above that point. Fig. 2.

It was determined that the maximum sodium carrying capability of this unit was in the range of 12% if load could be reduced at night to aid slag shedding. The secondary superheater clear side spacing was 18 inches and the second bank reduced to 9 inches. The primary superheater clear side spacing further reduced to 4-1/2 inches. During 1976 the primary superheater side spacing was opened up to nine inches, which aided in reducing the pluggage experienced in the primary superheater.

Water Lancing

Furnace slagging initially was a problem and the use of water was experimented with following startup during 1966, utilizing and building on the German experience that the stresses associated with uncontrolled quantities of water on a bare (non-slag coated) tube would lead to abruptly shortened tube life, with failures resulting from spot cooling, was adequately demonstrated by a membraned element during these trials. (1)

Further experiments led to the development of a water lance, which allowed controlled quantities of water to be applied to slag deposits for controlled periods of time which did not result in catastrophic tube metallographic damage, or appreciably shorten the life of the tubes.

A finite element theoretical stress analysis study was performed to determine the stress-time history of the furnace during a water lancing (quenching) cycle using a "worst case" approach, which was based on actual field measurements.

The furnace wall consists of a series of tubes interconnected by fins. When exposed to water quenching, the tube undergoes a thermal transient. Thermocouples have been used to measure the transients existing on the furnace side of the wall. This data was used in the finite element analysis to establish the thermal boundary conditions. Both single step and saw-tooth temperature profiles were analyzed using the actual measured surface temperatures, 720°F steady state and a low of 670°F when lanced, which gradually returned to the 720°F steady state. The stress loading included tube pressurization (1850 psi internal) as well. This analysis confirmed field observations and metallographic studies that indicated that tubes could withstand cyclic thermal stresses due to water lancing if additional transients were held near levels actually measured. Fig. 3. These results confirmed the importance of controlled dwell time, water quantity and bare vs slag-covered tubes as variables that had to be controlled. The water lancing permitted the unit to carry up to 12% Na_2O in the ash without inhibiting MCR (Maximum Continuous Rating) carrying ability for periods up to 12 hours. In retrospect, it now appears that the high sodium carrying ability of this unit must be related to the cycle conditions which required a low pressure (1275 psig) unit, low secondary superheater outlet temperatures (950°), which resulted in secondary superheater tube metal temperatures lower than a 2600 psig 1000F/1000F cycle would have required. The lower tube metal temperatures had to contribute to the reduction in bonding strength of the fouling deposits for this unit.

Limestone Injection

Saskatchewan Power, using a fuel similar to North Dakota lignites, reported success in altering slagging/fouling characteristics of the fuel by dosing the fuel with calcium carbonate (limestone) on a periodic basis. Ottertail Power Company

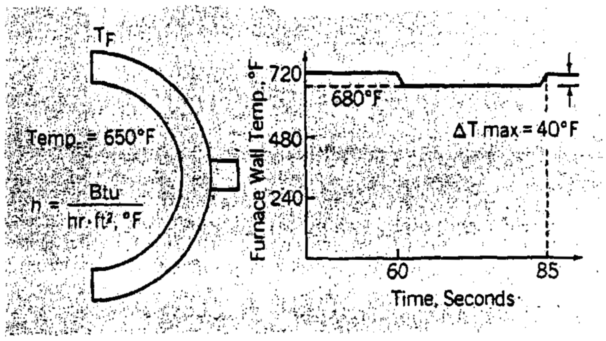


Fig. 3 Finite element water quench analysis

decided they, too, would like to try this approach on one of the units at Hoot Lake Station. At about the same time K. Hein of RWE (Germany) indicated that it was possible to reduce the SO_2 emissions with limestone injection when firing brown coal. We have performed many studies involving additive injection for sulfur dioxide control, both on our own and under the sponsorship of the National Air Pollution Control Administration, Department of Health Education and Welfare (1970). (2) The majority of coals utilized in our test were bituminous from the central part of the United States, but one sample from Mercer County was a North Dakota lignite with 0.7% sulfur. Pilot scale tests in our laboratory indicated that a 13% reduction in SO_2 emissions could be obtained with this North Dakota lignite and up to 50% SO_2 reduction could be obtained on bituminous fuels. The bituminous laboratory pilot scale percent reduction could not be duplicated in the field because of the high flame temperatures present with the bituminous fuel. The lignite field verification was never made. It was desirable to determine if Hein's findings on the German brown coal with its relatively low flame temperature could be duplicated in a North Dakota lignite flame. Therefore, our desire to check the effect on SO_2 emissions, coupled with the client's desires to quantify the limestone ($CaCo_3$) dosage effect upon fouling/slagging bonding strengths, were matched. A short test was undertaken during February and March of 1979, with The Department of Energy Research Center at Grand Forks participating. The test procedure followed at the Hoot Lake Station was to add 150 lbs. limestone (1/8 inch x 0) every two hours to a coal feeder. The limestone was injected into the coal feeder in about 30 seconds. The limestone and coal mixture flows to the pulverizer and then to the burner. The Canadian experience indicated that batch feeding is the most successful method in reducing bonding strengths, but the limestone addition did result in

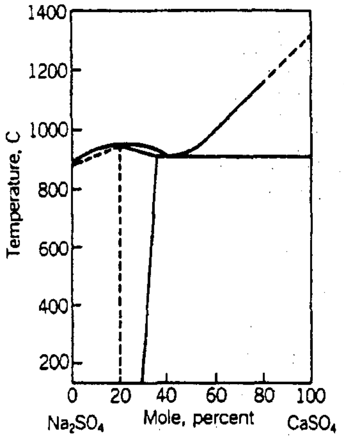


Fig. 4 Phase diagram, Na_2SO_4 - $CaSO_4$

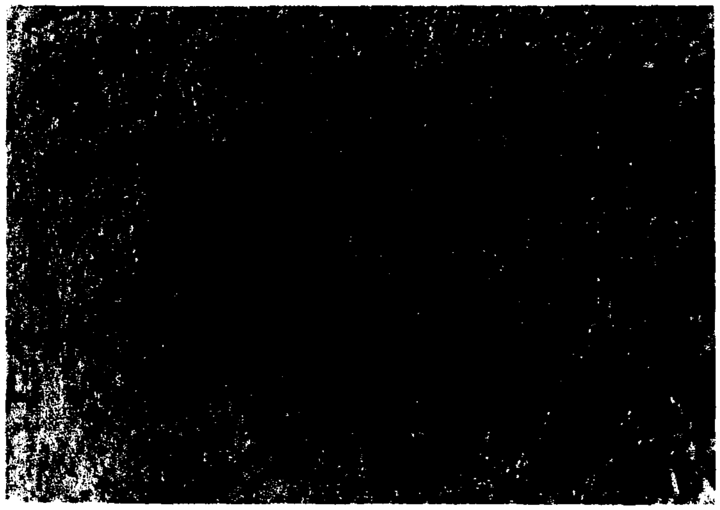


Fig. 5 Reheater ash deposit

pluggage of their regenerative airheaters. This has not occurred to date on the Hoot Lake tests but it appears that we have not been able to reproduce Hein's percent SO2 reduction, which we attribute to the lignite's lower moisture/higher flame temperatures. The new source performance standards in the USA, which require a 70% reduction, would force the addition of a scrubber in any case.

The results indicate that limestone definitely improves the cleanliness of the unit for a shutdown, but no one has been able to quantify the reduction in operational fouling (if any) that might be occurring. The benefit of a cleaner unit for outage work is an important one and the open question that remains is, could the same benefit be obtained if dosing commenced 24, 48 or 60 hours before the outage? We do not understand the detailed relationship between Na2SO4-CaSO4 but believe the mixture acts as the glue that bonds flyash particles together to form superheater deposits. This mixture has a relatively low melting temperature range of 884°C to 927°C over a wide range of sodium concentrations. The deposit formed by the Na2SO4-CaSO4 mixture and flyash sintered at high temperatures forms a very hard, bonded deposit and we already know that as the sodium content of the lignite increases both its deposition rate and its sintering strength increase. The phase diagram, Fig. 4, shows that low temperatures occur for sodium concentrations of 60 to 100% mole percent but as the calcium sulfate is increased above 40 mole percent, the melting temperature of the mixture increases. Our theory, based upon the phase diagram, indicates that if the calcium portion of the Na2SO4-CaSO4 mixture were increased enough, ash particles entering the superheater would be drier and fouling would decrease. Fig. 5 is a magnification of a polished section of a reheater deposit taken from a boiler burning North Dakota lignite. You may observe how the ash particles are bonded together. Fig. 6 is an analysis of this deposit.

We have designed a limestone injection system for a 450 megawatt steam generator (latest generation) which will be installed sometime during 1980 by Ottertail Power. It is our joint desire to test the effect of limestone dosing on a large unit with more severe cycle conditions; 2600 psig pressure levels 1005F/1005F steam temperature levels.

	Mole Percent
SiO_2	14.0
Al_2O_3	4.7
TiO_2	0.2
Fe_2O_3	2.5
CaO	18.2
MgO	5.2
Na_2O	16.0
K_2O	1.7
SO_3	37.5

Fig. 6 Reheater ash deposit analysis

Cyclone Application

To better address the observed slagging and fouling characteristics of the North Dakota lignites experienced in the pulverized coal fired units, could a different firing system be applied with better results? It had been determined that the low ash fusion temperature was compatable with a cyclone furnace. The application of the cyclone would reduce the ash loading to the convection pass which should reduce the fouling because the ash deposition rate would have to be lower. Offsetting the decrease in convection pass ash loading was the need for a complicated pre-drying system. Increasing moisture content reduces flame temperature in cyclones and this would place a lower limit on the unsupported firing rate required to maintain satisfactory tapping. Applying the pre-drying system, with separate (from the cyclone) moisture laden air venting, has allowed the cyclone to be successfully applied to fuels containing up to 40% moisture. Prior to commercial application, Glenharold Mine lignite was successfully fired in our works cyclone furnace (3). The initial application was to a 257 megawatt unit and was totally successful, in that the unit could operate continuously at MCR and demonstrated availability in excess of 90% over the last 6 years and slag tapping was not a problem. Based upon this successful operational experience, our management then allowed us to offer the cyclone furnace as the commercial product for utilization of these fuels. We had wanted to determine if cyclone firing was the answer to ash deposition and fuel preparation problems. Initially, it was not possible to fully experiment at the 257 megawatt unit because the coal seam being mined was relatively low in sodium (maximum up to 1977 was 3-1/2%).

The first of the second generation cyclone furnace units was installed at the Ottertail Power Company's Big Stone plant, as Unit No. 1. It is rated at 430 megawatts and has now operated for approximately three years.

High Pressure Cycle

A cooperative program with the Ottertail Power Company was undertaken at the Big Stone plant to gradually increase sodium oxide ash quantities and observe results from fouling, after all of the "state-of-the-art" de-slagging devices available were installed and operable. Unit No. 1 at the Big Stone plant is a 2620 psig superheater outlet pressure steam generator rated at 3,075,000 lbs steam/hr at 1000°F main steam and 1000°F reheat. Fig. 7.

This design was changed slightly from the 257 MW first cyclone by removing the cyclone riser tubes from the furnace to avoid any possibility of "slag catchers". The cyclone risers in the furnace act as "pumpers" on a natural circulation fluid flow design but we had two concerns: i.e., they

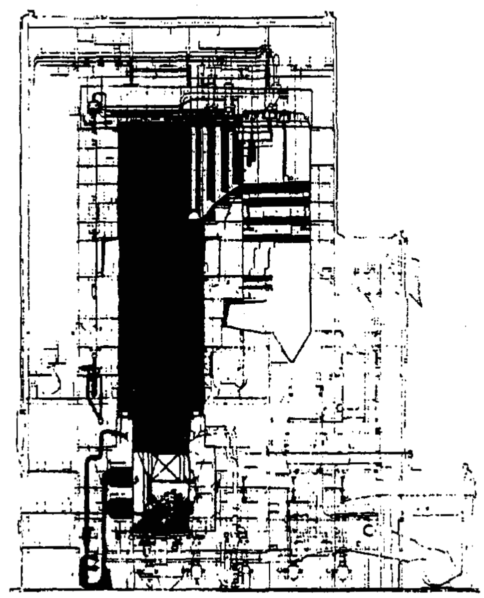


Fig. 7 High sodium lignite, cyclone application

could act as slag catchers and they could become so slag covered that the heat input, density differential or pumping head would be reduced and circulation would be affected. To avoid those possibilities, four pumps were provided to assist in circulation.

The unit burns coal from one mine which is delivered by unit train from a strip near Gascyone, North Dakota. Sodium content in that lignite varies from less than 1% to 8%. A typical analysis is attached. Fig. 8. The mine has been mapped sufficiently to know exactly where high sodium/medium sodium concentrations are located and, therefore, blending is a possibility.

The steam generator could operate continuously at the maximum rating of 3,100,000 lbs/hr steam flow with sodium content in the coal ash up to 4.5%. If the sodium content of the coal increased above 4.5%, the unit could not continue at MCR for any length of time before deposits in the superheaters began to bridge across the superheater tubes. Initially (1975-76), unit load was limited to 380 megawatts (of 430) because of troubles associated with the turbine generator. Running well below MCR, slagging and fouling were not a problem, irrespective of the sodium contents of fuel utilized. During the second year of operation at MCR, slagging and fouling did become a problem at the higher sodium levels in the fuel and a planned program of sootblower additions was undertaken in October, 1977.

		Actual Ranges			
Ash Fusion Temperatures, F		2100 - 2390			
Ultimate Analysis, %			Ash Analysis, %		
Ash	6.46	9-14% (Range)	SiO_3	17.1	
S	0.82		Al_2O_3	12.6	
H_2	2.54		TiO_2	0.2	
C	37.25		Fe_2O_3	6.6	
H_2O	41.30		CaO	23.3	
Na	0.42		MgO	7.9	
Oa	11.21		Na_2O	3.8	3-8% (Range)
Total	100%		K_2O	0.3	
Btu/lb	6255	5500 - 6600	SO_3	27.0	

Fig. 8 Gascyone lignite analysis

Design Changes

The blower additions were evaluated in December of 1977 and January, 1978. This evaluation indicated that with increasing sodium above 4.5%, the additional blowers had not really solved the problem, but only extended the time that it was possible to operate at MCR continuously. Loads still had to be shed on selected nights to allow a change in the tube metal temperatures and gas temperatures, so that the accumulated deposits could be removed. During the evaluation period, experiments were conducted to increase the effectiveness of the deslaggers. Sootblower speeds were increased from 70 inches/min to 140 inches/minute and the helical path was changed from 8 inches to 4 inches. The sootblowers cleaned as well at the faster speeds and the more rapid transients allowed the blowers to be used more often. Nozzle sizes were all changed to 1-1/4 inch and blowing pressures in the horizontal convection pass were set at 185 psig (retractables) and 200 psig (wall blowers). The client had developed expertise in manually removing deposits with shotguns and water lances.

Two additional design changes had been instituted during the October outage. First, remove the wraparound tubes holding the tube bundles together in the superheater and replacing them with split alignment castings which presented much less surface on which deposits could build. Second, to place sections of stainless steel and chromized tubes in the reheater leading edge tubes to test the deposit bonding strength theory, which again through observation indicated that the bonding strength between a deposit and austenitic steel is much less than that which is created between a deposit and ferritic steel. If the bonding strength is reduced the deposit is easier to remove.

Our evaluation was that the changes were not sufficient to maintain MCR 24 hours a day when burning a lignite containing above 4.5% sodium in the ash. It was decided to use water as a cleaning medium in the furnace and selectively in the convection pass. Actual analysis of water wall tubes subjected to twelve years of controlled water lancing, coupled with the theorectical finite element stress study, convinced us that the risk of damage to the water wall (furnace) tubes was extremely low. The thermal gradients present in superheater and reheater tubes are larger than those between water and furnace tube metal temperatures and we expect a greater risk of damage from uncontrolled water lancing in those areas.

In January of 1978 the sootblowers were arranged as shown in Fig. 9. Ninety-six long retractable sootblowers were located in the horizontal convection pass. Thirty of these were water-tempered blowers and were located on the left-half of the secondary superheater and reheater. Eighteen of these were water blowers arranged in front of the SSH. The water blowers were all run at a speed of 70 inches/minute.

The water tempering concept advanced by the sootblower vendor addressed the thermal stresses/ tube life concern held by B&W and their desire to reduce the cooling requirements (more stringent than the cleaning requirements) on the sootblower lance in the high gas temperature zones. They wished to utilize limited quantities of water, i.e., maximum 20% water by weight, exiting from the nozzles, which we could accept on a test basis. The thermal stress/tube life concerns were addressed in one other way. If water could be directed at a tube with deposits on it, the thermal gradient and resulting stress would not be as large as if the water had impinged directly upon a bare

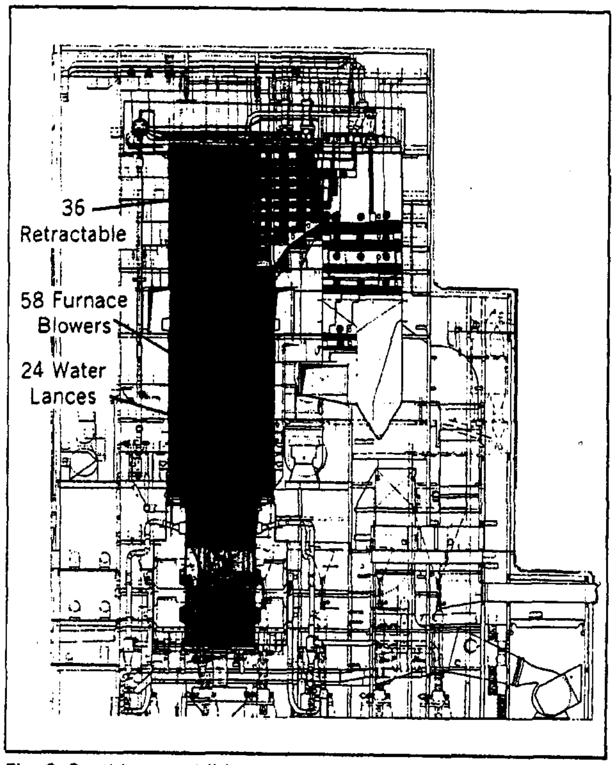


Fig. 9 Sootblower additions

tube. Traditional deposits on the high temperature surface have always increased towards the direction of gas flow. The upstream tube face is usually clean bare metal. Once oscillating retractable water blower was developed for insertion in the SSH sections which would blow only when facing downstream.

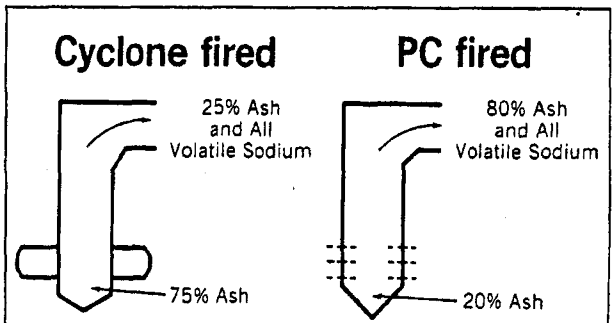
On the furnace walls a combination of short retractable water blowers surrounded by traditional steam blowers was felt to be the best application, where water followed by steam would be the most positive method that could be used to remove the deposits.

Cyclone Performance Related to Fouling

Our design experience indicated that the cyclone furnace should be the right choice for this difficult fuel, however, the actual operating experience gained from the Big Stone plant indicated otherwise. We were curious as the cyclone furnace did perform as expected, but the reduction in the deposition rate did not reduce the fouling problem in the convection passes.

It was decided to test a mine mouth cyclone unit and a pulverized coal unit located side by side, burning the same fuel. Cycle conditions were approximately the same for both steam generators, but the P.C. unit was rated @ 216 MW and represented design state-of-the-art in 1962 while the cyclone was 430 MW. Both units were designed and supplied by Babcock & Wilcox and are located at the Basin Electric Power Cooperative's Leland Olds Generating Station. The Department of Energy, Grand Forks, Basin Electric and Ottertail Power Companies, Babcock & Wilcox and Diamond Power were jointly involved.

The results of those tests indicated, as predicted, that the deposition rate on the PC unit was at least 2 times greater than the deposition rate measured on the cyclone fired unit. (4). The ash deposits taken by the Department of Energy were not, however, analyzed for sintering strengths which we felt are a most important criteria of cleanability. Following those tests, which did not produce sintering strengths, we obtained deposit samples from the pulverized coal units at Basin Electric and from the cyclone fired unit at Big Stone. Once corrections for the differences in the coal were made it was determined that sodium enrichment in the deposit was taking place in the cyclone unit to a greater extent than in the pulverized coal unit. Fig. 10. We postulated that the sodium compounds in the ash volatized at relatively low temperatures, in fact as low as 1620°F and therefore, the gaseous sodium goes with the gases to the convection pass. The cyclone unit has at least 75% of the ash going to the bottom tap and there is, therefore, less ash available to dilute the sodium in the convection passes where it condenses and aids in



Cyclone fired

	Fly Ash	Coal Ash
SiO_2	27	22
Al_2O_3	11	10
Fe_2O_3	3	5.0
TiO_2	0.7	0.5
CaO	18.0	19
MgO	8.0	8
Na_2O	10.2	5.2
K_2O	0.53	0.30
SO_3	11.9	25.2

$\frac{Na_2O \text{ Fly Ash}}{Na_2O \text{ Coal Ash}} = 1.96$

PC fired

	Fly Ash	Coal Ash
SiO_2	24	20
Al_2O_3	10	9
Fe_2O_3	10	9
TiO_2	0.4	0.4
C_2O	27	24
MgO	7	5
Na_2O	9.2	10.2
K_2O	0.4	0.5
SO_3	–	21.0

$\frac{Na_2O \text{ Fly Ash}}{Na_2O \text{ Coal Ash}} = 0.90$

Fig. 10 Convection ash deposits, sodium enrichments forming extremely hard deposits on the tubes. The pulverized coal unit has demonstrated an ash split of about 80% to the convection passes, where it can act as a diluent for the sodium, keeping the concentrations down, which results in reducing the strength of the PC fouling deposits below those found on the cyclone units.

Jointly the client and ourselves decided to run a maximum sodium carrying ability test on the large cyclone steam generator to determine just what Na_2O levels could be carried with the unit held at MCR and with all the design changes previously described installed.

Maximum Sodium Test

The testing schedule required 5% sodium lignite to be burned for the first four days, with 1% incremental increases every four days up to 8% Na_2O maximum. Following that phase, the high sodium lignite (8%) would be burned for one to two days, followed by several days of 6%, during which time a MgO additive would be injected into the furnace. Full load was to be maintained throughout the test period or until such time as the client, or B&W, felt there was a danger of plugging the unit.

Actual testing began on May 4, 1978 with a clean unit and ran until coal blending (reducing sodium) and intentional load drops began on May 19 for cleaning purposes. Additional load drops were encountered during the test, the result of a damaged circulation pump and low power demands. Sodium levels averaged 5.6% for the first four day period, 6.0% for the second, 6.3% for the third and 7.1% for the remaining three days, and were completed May 17, 1978. The MgO additive test commenced May 17 and was aborted May 19.

Results

1. The water blowers in front of the secondary superheater kept the first bank of secondary superheater clean and open.
2. The stainless steel leading edge tubes in the secondary superheater and reheater stayed cleaner than the associated ferritic tubing.
3. The loss of a circulation pump reduced MCR to 370 MW on the 5th test day at 6.2% Na_2O level. Removal of No. 11 feedwater heater allowed inputs to be raised and increase output to 385 MW. The lower load (below MCR) from the 5th day to 14th test day had to affect gas side temperatures and influence slag shedding ability. The 14th day sodium levels were at 7.1% Na_2O.
4. The reductions in load on many nights, due to lack of demand, influenced slag shedding ability.
5. The furnace was clean and did not have heavy slag deposits at any time during the test.
6. The water-tempering blowers were not any more successful in removing deposits than those using straight steam.
7. The oscillating water burner is as successful as the water blower in removing deposits. Fig. 11.

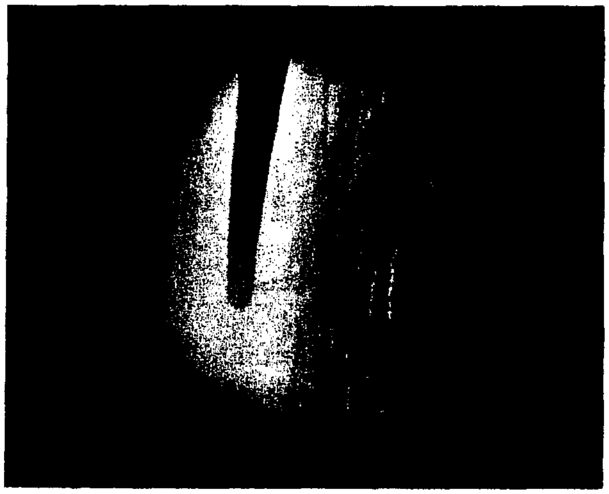


Fig. 11 Oscillating sootblower removing secondary superheater deposit

The maximum sodium carrying ability test was stopped May 17, and while the above items, #3 and #4, clouded the results, it was our evaluation that the unit could maintain MCR for several days at Na_2O levels below 6%. If nightly load reductions were permitted for shedding the daytime MCR could be held continuously.

The second test, the addition of an MgO additive into the furnace to determine its effect on cleanability of the slag and fouling deposits in the unit was started May 17. A tank car of MgO additive and four metering pumps were purchased. The MgO injectors were set up to inject the MgO into the furnace just above the cyclones, adjacent to the point where the coal fines and moisture were vented from the pre-drying lift line system. When all four metering pumps were operational, they supplied 670 pounds MgO/hr, or about 920 ppm MgO, based on an average coal flow of 365 tons/hr. The MgO dosage rate was established by the vendor (Basic Chemicals) as a result of successful deposit removal obtained on another unit

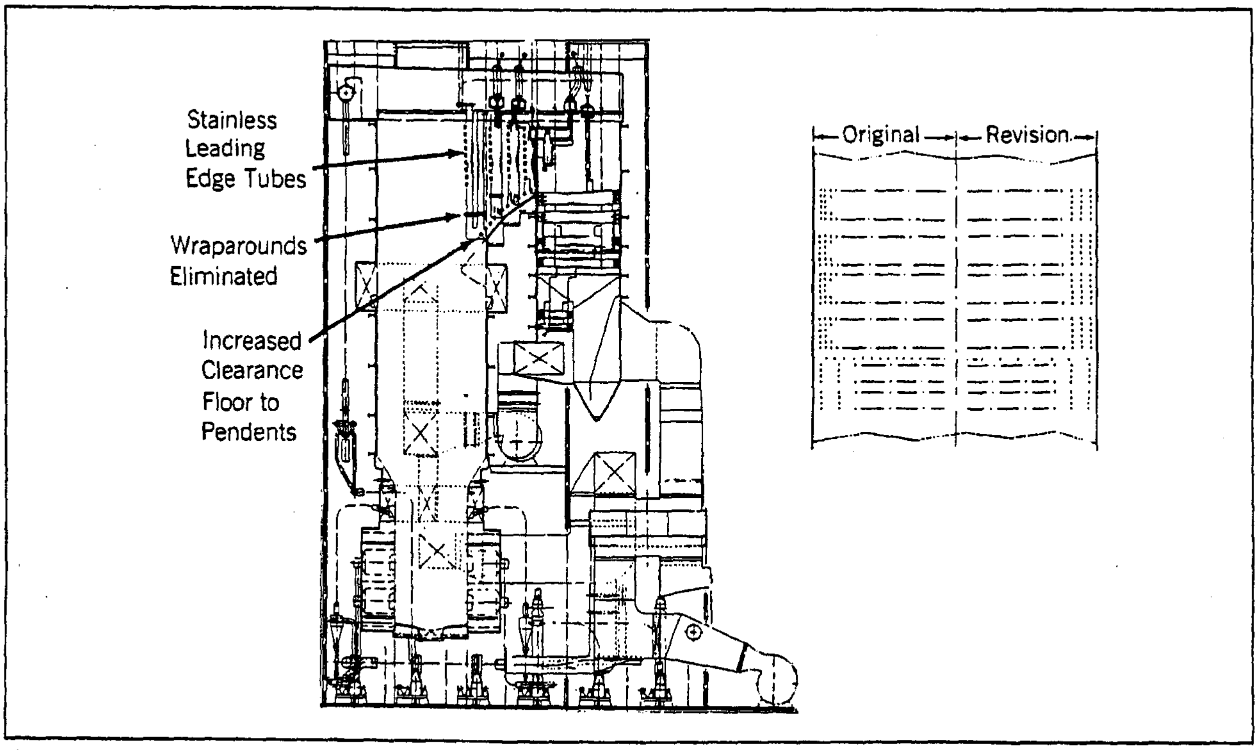


Fig. 12 High sodium lignite updated cyclone application

burning a high sodium lignite. This test probably was not a good test, in that the heat transfer surfaces were not bare metal clean prior to the addiction of MgO, but the vendor believed that the additive was good enough to reduce the overall fouling conditions starting with dirty tubes. Thirty hours after the feed commenced, deposition was out of control. The state-of-the-art boiler cleaning equipment that had been installed for the maximum sodium capability test did not remove deposits fast enough to prevent convection pass pluggage. The largest amount of deposits were in the hot leg of the secondary superheater and at the entrance of the reheater. The deposits were beginning to become large enough to bridge across the superheater tubes and it was decided to discontinue the MgO additive test. The bunkers were filled with a low sodium coal (3-1/2%) and load was reduced, which resulted in convection pass cleanup with deposition under control again.

The next unit in this generation of 450 megawatt cyclone fired North Dakota lignite boilers, Coyote, had already been sold and was modified during the design stages to take advantage of everything that had been learned on the Big Stone test. Fig. 12. Namely; all the sootblowers added to Big Stone have been added initially to the Coyote Unit, leading edge tubes of both the secondary superheater were fabricated from stainless steel, the wraparound tube ties were removed to remove the slag build-up areas, the blower speeds were increased to 140 in/min, the nozzles were changed from lead/lag to straight on and sized for 1-1/4 inch, water blowers have been placed in front of the secondary superheater, and water lances were installed in the furnace. The unit should start commercial operation sometime in the latter part of 1980 and we expect it to be suitable for up to 6% sodium in the ash. The results of the limestone injection tests on the close duplicate unit at Big Stone will be applied if results are encouraging.

Analysis of all this field data indicates now that a PC unit designed to the same convection pass conditions as a cyclone unit (same cycle conditions), but fortified with the dilution effects from the higher ash loadings, should be capable of carrying a higher sodium level at MCR than the associated cyclone unit. How does the analysis of this field data direct us towards a new boiler design that could be applied to fuels as difficult as those of the North Dakota fields?

New Steam Generator Design

The Hoot Lake pulverized coal (66 MW) unit was capable after modifications of handling sodium up to 12% in the ash, but the LeLand Olds pulverized coal unit (216 MW) appeared to top out at about 7% Na_2O, if the ground rules of long term

MCR and no load reduction for shedding are in effect. The major difference is in the cycle conditions to which the units were designed. Those cycle conditions translate directly to maximum tube mean metal temperatures in the final superheaters and final reheaters. The gas side design temperature levels are similar for both units, clear side spacing is similar, fuel is similar, but the sodium carrying levels are different, even with selective water blowing. Fig. 13.

	Hoot Lake	Leland Olds
MW	66	216
Pressure, psig	1275	2475
Stm. temp., °F	955	1005/1005
1st SSH ss, inches	18 (988 Tm) (2160 Tg)	18 (956 Tm) (2120 Tg)
2nd SSH ss, inches	9 (1003 Tm) (1980 Tg)	9 (1103 Tm) (1970 Tg)
1st RH ss, inches	—	6
2nd RH ss, inches	—	41/2
Pri SH ss, inches	41/2 (1027 Tm) (1750 Tg)	41/2 (949 Tm) (1216 Tg)

Fig. 13 Thermodynamic cycle effect upon tube metals

Fouling considerations mandate a design EGT (exit gas temperature) lower than 2150° MHVT. This level was met for all our severe fouling designs, but field results indicate it was still not low enough to permit carrying the higher sodiums (+7%) and continuous MCR. The thermodynamic situation precludes further reduction in the EGT for these cycles on a drum type unit. As the furnace size increases, (to lower the EGT), the economizer can be made smaller to produce the same amount of steam, until, at some point an economizer would not be required, and, therefore, was not supplied on the Basin pulverized coal unit. If the furnace is further enlarged to reduce furnace exit gas temperature, too much saturated steam would be produced and there would be insufficient heat left in the flue gas to make design superheat and reheat steam temperatures.

This can be illustrated by looking at the amount of heat required for the superheater and reheater. A very simple heat balance may be made for the superheater and reheater.

$$QSteam = QGas$$

which simply states that the heat absorbed by the superheater and reheater equals the heat given up by the gas. For the boiler shown in Fig. 12 where the furnace is all boiler surface, the gas side can be further defined as shown in Equation 2;

$$Qs = Wg\,(Cg)\,(Tg1\text{-}Tg2)$$

where:

Qs = Heat absorbed by the superheater and reheater. (Technically, heat absorbed by water cooled walls and screens downstream of the furnace exit, while not significant, must be added to the superheater and reheater requirements.)

Wg = Weight of gas flowing over the superheater and reheater.

Cg = Specific heat of the gas.

Tg1 = Gas temperature leaving the furnace or entering the superheater.

Tg2 = Gas temperature leaving the last superheater or reheater bank.

Steam enters the last superheater bank at essentially saturation temperature, which increases with drum pressure. Obviously, for heat transfer to take place from the gas to the steam, the gas temperature leaving the last superheater bank (Tg2) must be higher than the entering steam temperature. There is an economic and functional minimum temperature difference between Tg2 and saturation temperature on the order of 125°F to 180°F. Thus a minimum value of Tg2 can be defined. Referring back to Equation 2, it can be seen that the cycle requirements for superheat and reheat absorption, combined with an economic and practical limit on the gas temperature leaving the last superheater bank (Tg2), establish the minimum gas temperature leaving the furnace (Tg1) and thus the maximum furnace size and/or absorption.

The absorption requirements for the various heat cycles can be translated into minimum required gas temperature levels leaving the furnace to produce the required superheat and reheat temperatures.

The class of coal fired will result in a relative change in minimum gas temperature required for various typical heat cycles. For a constant boiler output, the gas weight and specific heat of the flue gas is higher for subbituminous and lignitic coals than for a low moisture bituminous coal. Therefore, they offer the potential for the designing of lower gas temperature levels than a bituminous coal.

Considering now a single fuel, a North Dakota high sodium lignite, the maximum permissible gas temperature (TgSL) based on the slagging and fouling characteristics of this fuel can be superimposed on this plot. (Fig. 14) What can be done for the high pressure/temperature cycles when the maximum temperature limit for slagging and fouling (TgSL) is less than the temperature required for superheat and reheat (Tg1)? Several of the most often used methods are:

1. Replace water cooled furnace with steam cooled (superheat) surface.

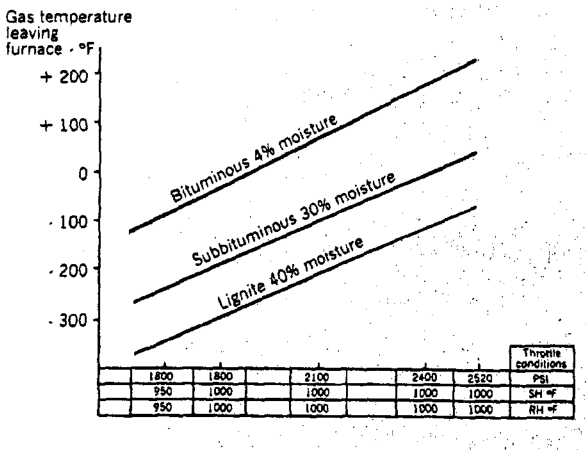


Fig. 14 Relative furnace exit gas temperatures

2. Recirculate flue gas.
3. Burner manipulation.
4. Gas by-pass and damper control.
5. Spray attemperation.
6. Excess air.

Methods 2-6 have been used to lower furnace exit gas temperatures and match cycle requirements on our present designs for severe fouling lignites. Method 1, replacing saturated furnace surface with steam cooled surface, would be a new approach to a more flexible furnace exit gas temperature and still meet the required cycle conditions for minimizing net plant heat rates.

The once-through Universal Pressure (UP) boiler design can be considered a special case of superheat surface in the furnace. Fig. 15 shows a subcritical once through boiler of the spiral furnace circuitry design where the fluid leaving the top of the furnace enclosure is somewhat superheated. This design makes it possible to begin superheating steam in the upper furnace. The need to maintain a useable temperature differential in the backend would not affect the minimum Furnace Exit Gas Temperature in this case. The final main steam temperature is dependent solely upon the ratio of heat input and feedwater.

Application of the sprial UP furnace to the North Dakota lignites would allow gas temperature reduction to 1920°F MHVT entering the 24 inch side spaced superheater and 1710°F MHVT entering the 12 inch spacing. The unit could be run at reduced outlet steam temperatures if lower metal temperatures are required to reduce fouling, without spray attemperation getting out of control. Full steaming capacity could be maintained at the lower steam/tube metal temperatures which would allow slag shedding with minimal

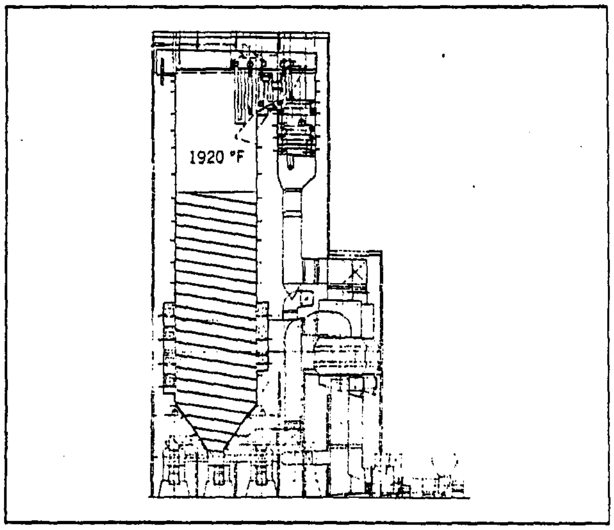


Fig. 15 Once-through steam generator

load reduction. It would not be necessary to hang platens in the upper furnace because the initial superheating is, with this design, started in the furnace circuits.

The application of this design to the North Dakota lignites has not yet been made. The UP boiler type, pulverized coal fired, has been applied to Texas lignites and we expect it to successfully handle higher sodiums than previously possible in the high pressure/temperature cycles that are required today to maintain low plant heat rates.

Reference

(1) McQuarrie, C.; Locke, J.W.,; and Winkin, J.P., "Water Injection Cleaning Of Slag Deposits On A Lignite-Fired Boiler", American Power Conference, Chicago, Illinois, April, 1969.

Ellery, A.R.; Johnson, T.R.; and Newton, J.D., "Investigation Into The Likelihood Of Thermal Fatigue Damage To Furnace And Superheater Tubes Caused By On-Load Water De-slagging" ASME Paper No. 73 WA/CD-5, 1973.

Gray, R.J. and Moore, G.F., "Burning the Sub-Bituminous Coals of Montana and Wyoming in Large Utility Boilers", ASME Paper No. 74-WA/FU-1, New York, NY, November, 1974.

Gronhovd, G.H., Harak, A.E., and Tufte, P.H., "Ash Fouling and Air Pollution Studies Using A Pilot Plant Test Furnace", Bureau of Mines Information Circular 8471, Technology and Use of Lignite, Proceedings: Bureau of Mines, University of North Dakota Symposium, Grand Forks, N.D., May 1-2, 1969, pp 69-88.

(2) Attig, R.C. and Sedor, P., "Additive Injection For Sulfur Dioxide Control, A Pilot Plant

Study", Department of Health, Education and Welfare order 4078-01, March, 1970.

(3) Duzy, A.F., "Characteristics Of High Moisture Fuels Cyclone Furnace Application", Lignite Symposium, Grand Forks, North Dakota 1967.

(4) Sondreal, E.A., Selle, S.J., Tufte, P.H., Menze V.H., Laning, V.R., "Correlation of Fireside Boiler Fouling With North Dakota Lignite Ash Characteristics And Power Plant Operating Conditions", American Power Conference, Chicago, Illinois, April, 1977.

Acknowledgements

The author thanks the Basin Electric Power Cooperative, the Ottertail Power Company, The Department of Energy Research Laboratory, Diamond Power Specialty Corporation and Basic Chemicals for their cooperative assistance during many of the activities herein reported.

UNIT DESCRIPTION

PLANT

This unit is installed as Unit No. 5 at the Crystal River Plant located near Crystal River, Florida. Plant elevation is 11 feet above sea level.

The unit supplies steam to a GE turbine rated at 665 MW. The consulting engineer is Black & Veatch, Kansas City, Missouri.

BOILER

This is a semi-indoor, balanced draft Carolina Type Radiant Boiler designed for pulverized coal firing. The unit has 54 Dual-Register burners arranged in three rows of nine burners each on both the front and rear walls. Furnace dimensions are 79 feet wide, 57 feet deep, and 201 feet from the centerline of the lower wall headers to the drum centerline. The steam drum is 72 inches ID.

The maximum continuous rating is 5,239,600 lb/hr of main steam flow at 2640 psig and 1005° F at the superheater outlet with a reheat flow of 4,344,700 lb/hr at 493 psig and 1005° F with a normal feedwater temperature of 546° F. This is a 5% overpressure condition. The full load rating is 4,737,900 lb/hr of main steam flow at 2500 psig and 1005°F with a reheat flow of 3,959,800 lb/hr at 449 psig and 1005°F with a normal feedwater temperature of 535° F. Main steam and reheat steam temperatures are controlled to 1005°F from MCR load down to half load (2,368,900 lb/hr) by a combination of gas recirculation and spray attemperation.

The unit is designed for cycling service and is provided with a full boiler by-pass system. The unit can be operated with either constant or variable turbine throttle pressure from 63% of full load on down.

The design pressures of the boiler, economizer, and reheater are 2975, 3050, and 750 psig respectively.

Steam for boiler soot blowing is taken off the primary superheater outlet header. Steam for air heater soot blowing is taken off the secondary superheater outlet.

SCOPE OF SUPPLY

The major items of equipment supplied by B&W include:

- RBC unit pressure parts including boiler, primary and secondary superheater, economizer, and reheater.
- Fifty-four Dual-Register burners and lighters.
- Six MPS-89GR pulverizers and piping to burners.
- By-pass system including valves and piping.
- Two stages of superheat attemperators (first stage tandem) and one stage of reheat attemperation (2 nozzles); nozzles only, no block or control valves or spray water piping.
- Three Rothemuhle air heaters (one primary and two secondary).
- Ducts from secondary air heaters to windbox.

- Primary air system: two TLT centrifugal PA fans and ducts from fans to pulverizers.
- Gas recirculation system: one TLT centrifugal GR fan, one dust collector and flues.
- Six Stock gravimetric coal feeders and drives.
- Bailey burner controls.
- Safety valves and ERV.
- Brickwork, refractory, insulation and lagging (BRIL).
- Seal air piping and fans.
- Erection.
- Recommended spare parts.

FUEL

The guarantees for this unit are based on firing a 50/50 blend of Eastern bituminous and Western sub-bituminous coal. The performance coal is classified as high slagging and medium fouling. Performance was also checked on Illinois deep-mined coal which is classified as severe slagging and high fouling. The furnace and convection pass are designed for a severe slagging and severe fouling coal.

Ultimate Analysis: % by Weight

	Performance	Illinois
Ash	7.90	13.00
Sulfur	0.49	4.20
Hydrogen	3.90	4.40
Carbon	58.80	62.00
Chlorine	0.03	0.02
Water	18.50	10.00
Nitrogen	1.10	1.38
Oxygen	9.28	5.00
Total	100.00	100.00
Higher Heating Value	10285 Btu/lb	11000 Btu/lb

PEF-FUEL-004091

RB-603

A — FUEL AS FIRED

SAMPLES			
ANALYSES 50/50 BLEND, EASTERN & WESTERN			
KIND			
ASTM — CLASS			
ASTM — GROUP			
SOURCE — MINE			
SOURCE — SEAM			
SOURCE — DISTRICT			
SOURCE — COUNTY			
SOURCE — STATE			
COAL — SIZE			
GRINDABILITY			48
SURFACE MOISTURE, %			
			PERF.
ASH SOFT. TEMP., F (REDUCING)			
PROX. ANAL., % — MOISTURE, TOTAL			18.5
VOLATILE MATTER			31.0
FIXED CARBON			42.6
ASH			7.9
TOTAL			100.0

FUEL	BIT.	SUB-BIT.	
% BY	WT.	WT.	WT.
ASH	10.0	5.8	7.90
S	0.5	0.48	0.49
H_2	4.4	3.4	3.90
C	69.0	48.5	58.80
CH_4			
C_2H_4			
C_2H_6			
C_3H_8			
C_4H_{10}			
C_5H_{12}			
C_6H_{14}			
CO			
CO_2			
Cl	0.05	0.02	0.03
H_2O	7.0	30.0	18.50
N_2	1.4	0.7	1.10
O_2	7.65	11.1	9.28
TOTAL	100.00	100.00	100.00
BTU/LB	12,450	8,125	10,285
BTU/CU FT AT 60F 30 IN.HG			

*EXCLUDING VALVES AND STATIC HEAD.

B — PREDICTED PERFORMANCE

STEAM LEAVING SH, M LB/HR	2368.9	4737.9	5239.6
STEAM LEAVING RH¹, M LB/HR	2063.8	3959.8	4344.7
STEAM LEAVING RH², M LB/HR			
TYPE OF FUEL	PC	PC	PC
LOAD CONDITION	CONT.	CONT.	CONT.
EXCESS AIR LEAVING ECON., %	35	20	20
NO. OF BURNERS IN OPERATION	45	54	54
FUEL INPUT, MKB/HR	3348	6053	6581
HEAT AVAIL, MKB/HR (FUEL & HEATED AIR)	3615	6367	6886
QUANTITY, M LB/HR — FUEL (MCFH-NAT. GAS)	325.5	588.6	639.8
FLUE GAS ENTERING AIR HEATER	3728	6051	6579
AIR TO BURNING EQUIPMENT	3327	5419	5891
AIR HEATER LEAKAGE PRI/SEC	107/210	128/272	131/286
PRESSURE, PSIG — STEAM AT SH OUTLET	2425	2500	2640
STEAM AT RH¹ INLET	240	474	520
STEAM AT RH² INLET			
PRESSURE DROP — REHEATER 1	13	25	27
REHEATER 2			
ECONOMIZER *	5	20	25
DRUM TO SH OUTLET	39	155	189
TEMPERATURE, F — STEAM — LEAVING SUPERHEATER	1005	1005	1005
LEAVING REHEATER 1	1005	1005	1005
ENTERING REHEATER 1	528	598	604
LEAVING REHEATER 2			
ENTERING REHEATER 2			
LEAVING ECONOMIZER	630	689	697
FLUE — LEAVING AH (EXCL. LKG) PRI/SEC	280/260	280/278	280/279
LEAVING AH (INCL. LKG) PRI/SEC	258/249	261/267	262/269
WATER ENTERING ECONOMIZER	459	535	546
AIR — ENTERING UNIT PRI/SEC	85/99	95/82	95/80
LEAVING AIR HEATER PRI/SEC	555/555	575/596	579/601
RESISTANCE, IN. OF WATER — GAS — FURNACE & CONVECTION BANKS	1.7	3.5	3.9
FLUES TO AH OUTLET	0.4	0.9	1.1
AIR HEATER	1.7	3.6	4.1
TOTAL FURN. TO AH OUTLET	3.8	8.0	9.1
AIR — FUEL BURNERS & WINDBOX	1.0	2.5	2.9
DUCTS & FLOW METER	1.2	3.3	3.8
AIR HEATER	1.7	4.0	4.6
TOT. FROM AH INLET TO FURN	3.9	9.8	11.3
HEAT LOSS, % — DRY GAS	4.23	4.34	4.43
H_2 & H_2O IN FUEL	5.80	5.89	5.91
MOISTURE IN AIR	0.11	0.11	0.11
UNBURNED COMBUSTIBLE	0.30	0.30	0.30
RADIATION	0.31	0.17	0.15
UNACC. FOR & MFRS. MARGIN	1.50	1.50	1.50
TOTAL HEAT LOSS	12.25	12.31	12.40
EFFICIENCY OF UNIT, %	87.75	87.69	87.60
PULV. FAN & FEEDER — NO. IN USE PER BOILER	5	6	5	6
TOTAL POWER, KW HR/TON MOTOR OUTPUT			
% THRU 200 U.S.S. SIEVE	74	69	65	68

PREDICTED PERFORMANCE IS BASED ON COMBUSTION AIR ENTERING UNIT WITH 0.013 LB MOISTURE/LB DRY AIR, ON 29.92 IN. HG. BAROMETRIC PRESSURE, ON CONDITIONS & EQUIPMENT GIVEN ON THIS SUMMARY SHEET & ON ARRANGEMENT SHOWN ON DRAWING P12-4657-16Y0

C — EQUIPMENT PER UNIT

Line	Item	Value
2	TYPE	RADIANT
3–4	SIZE	RBC 57 79/HB
5	DESIGN PRESSURE - 2,975 PSIG	
6		
7	PRESSURE PART HEATING SURFACE, SQ FT — FURNACE — WATER COOLED SCREEN (CIRCUMFERENTIAL)	
8	WATER COOLED (PROJECTED)	48,736
9	SUPERHEATER (CIRCUMFERENTIAL)	
10	SUPERHEATER (PROJECTED)	46,442
11		
12	TOTAL FURNACE HEATING SURFACE	95,178
13	CONVECTION — SATURATED (CIRCUMFERENTIAL)	10,586
14	SUPERHEATER (CIRCUMFERENTIAL)	243,015
15	REHEATER 1 (CIRCUMFERENTIAL)	333,919
16	REHEATER 2 (CIRCUMFERENTIAL)	
17	ECONOMIZER	46,519
18	TOTAL CONVECTION HEATING SURFACE	634,039
19	TOTAL FURN. & CONV. PRESSURE PART. HTG. SURF.	729,217
20	FLAT PROJECTED FURNACE HEATING SURFACE	
21	TO FACE OF PLATENS (24" CTR)	73,581
22	TO FACE OF CONVECTION SURFACE	101,501
23	FURNACE VOLUME, CU FT	734,185
24	AIR HEATER — TYPE ROTHEMUHLE REGENERATIVE	NO. 1-PRI. 2-SEC.
25	TOTAL HEATING SURFACE, SQ FT	PRI.-250,522
26		SEC.-824,850
27	PRI. SIZE-10.6 Vu 56	
28	SEC. SIZE-12.5 Vu 68	
29	FUEL BURNER — TYPE DUAL REGISTER	
30	NO. 54	
31	PULVERIZER — TYPE MPS SIZE 89G NO. 6	
32	CAPACITY OF 5 PULV. IS 5239 M LB STEAM/HR BASED ON 48 GRIND	
33	10,285 BTU COAL AT 65 % THRU 200 U.S.S. SIEVE	
34	FOR 109.7 M LB COAL/PULV.-HR AT 65% THRU 200 U.S.S. SIEVE MIN. GRIND	
35	IS 42 MAXIMUM TOTAL MOISTURE IS 18% REQUIRING 570 F AIR	
36–38		
39	STEAM TEMP. CONTROL — MAIN STEAM BY SPRAY ATTEMPERATION	
40	REHEAT BY GAS RECIRCULATION	
41–42		
43	UNIT CONSTRUCTION FEATURES — MEMBRANE WALLS	
44	BALANCE DRAFT	
45–52		

REVISIONS NO.	DESCRIPTION	BY	DATE

FLORIDA POWER CORP.
CRYSTAL RIVER, UNIT 5

UTILITY BOILER PERFORMANCE SUMMARY

BY RLG APPD. [illegible] DATE

THE BABCOCK & WILCOX COMPANY

P12-4657-16Y0-1S0

Docket No. 060658-EI
Contract Summery
Exhibit No. ____ (JAB-9)
Page 3 of 7

PEF-FUEL-004092

BWFP 31751-3

THE BABCOCK & WILCOX COMPANY
FOSSIL POWER GENERATION DIVISION

CONTRACT INFORMATION SHEET

A.O.

TURBINE

MFG: G.E.
NAME PLATE RATING: 665,000 KW

HEAT BALANCE — PERFORMANCE DESIGN DATA

SPECIFIED BY: ☒ PURCHASER ☒ TURBINE ☐ BOILER DESIGN ☐

RATING: PERF. AT TERMINALS		GUAR. LOAD	PEAK LOAD ____ HRS.	MAX. CONTINUOUS LOAD	LOW LOAD CONTROL			MAX CONT HEAT INPUT
FUEL:		Blend		Blend	Blend	Blend		
FUEL QUANTITY	MLB/HR							
MAIN STEAM FLOW	MLB/HR	4737.9		5239.6	2368.9	947.6		
OPR. PRESS. @S.H. OUT.	PSIG	2500		2640	2425	2406		
STEAM TEMP. @S.H. OUT.	°F	1005		1005	1005	990		
1ST REHT. STEAM FLOW	MLB/HR	3959.8		4344.7	2063.8	842.4		
1ST REHT. ENTR. PRESS.	PSIG	474		520	240	84		
1ST REHT. ENTR. TEMP.	°F	598		604	528	410		
1ST REHT. OUT. PRESS.	PSIG	449		493	227	79		
1ST REHT. OUT. TEMP.	°F	1005		1005	1005	950		
1ST REHT ENTR. ENTH		1298.7		1299.2	1279.3	1232.6		
2ND REHT. STEAM FLOW	MLB/HR							
2ND REHT. ENTR. PRESS.	PSIG							
2ND REHT. ENTR. TEMP.	°F							
2ND REHT. OUT. PRESS.	PSIG							
2ND REHT. OUT. TEMP.	°F							
FEEDWATER ENTH.	BTU/LB							
FEEDWATER TEMP.	°F	534.8		546.4	459.4	372.3		
FEEDWATER FLOW	M LB/HR	4737.9		5239.6	2368.9	947.6		
S.H. SPRAY WATER TEMP	°F	355		362	310	265		
PRESS @ SOURCE								
1ST REHT. SPRAY WATER TEMP.	°F	355		362	310	265		
PRESS. @ SOURCE								
2ND REHT. SPRAY WATER TEMP.	°F							
PRESS. @ SOURCE								

QTY., TYPE & SIZE CUST. FEED PUMPS:
QTY., TYPE & SIZE CUST. START UP PUMPS:

STEAM TEMPERATURE CONTROL

	METHOD	RANGE	REMARKS
MAIN STEAM	Spray Attemperation	2368.9M To 5239.6M	
1ST REHT.	Spray Attemperation & Gas Recirculation	2368.9M To 5239.6M	
2ND REHT.			

4

SPECIAL PERFORMANCE OR DESIGN REQ'MNTS.

☐ NOT REQD. ☒ REQD.: SEE CIS-14.0

PERF. CURVES & DATA SHEETS

SEE CIS-100 SERIES

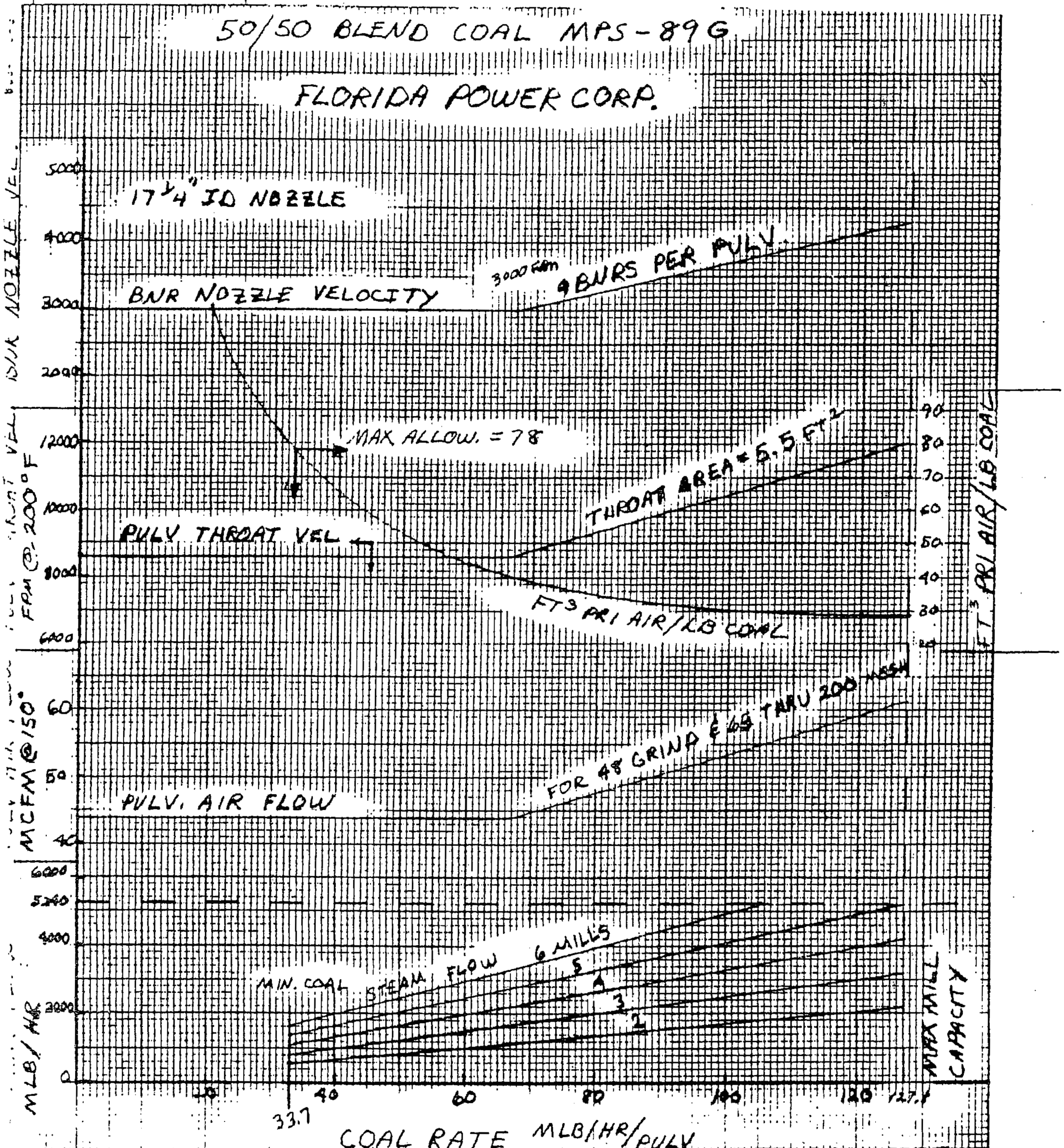
REL. NO. AND DATE	CONTRACT NO.	FILE NO.
1 1-21-80 2 4-18-80	334-0603	RB-603

UNIT PERFORMANCE DESIGN DATA

FPGD CIS-13.0 D

P-

THE BABCOCK & WILCOX COMPANY
CONTRACT INFORMATION SHEET



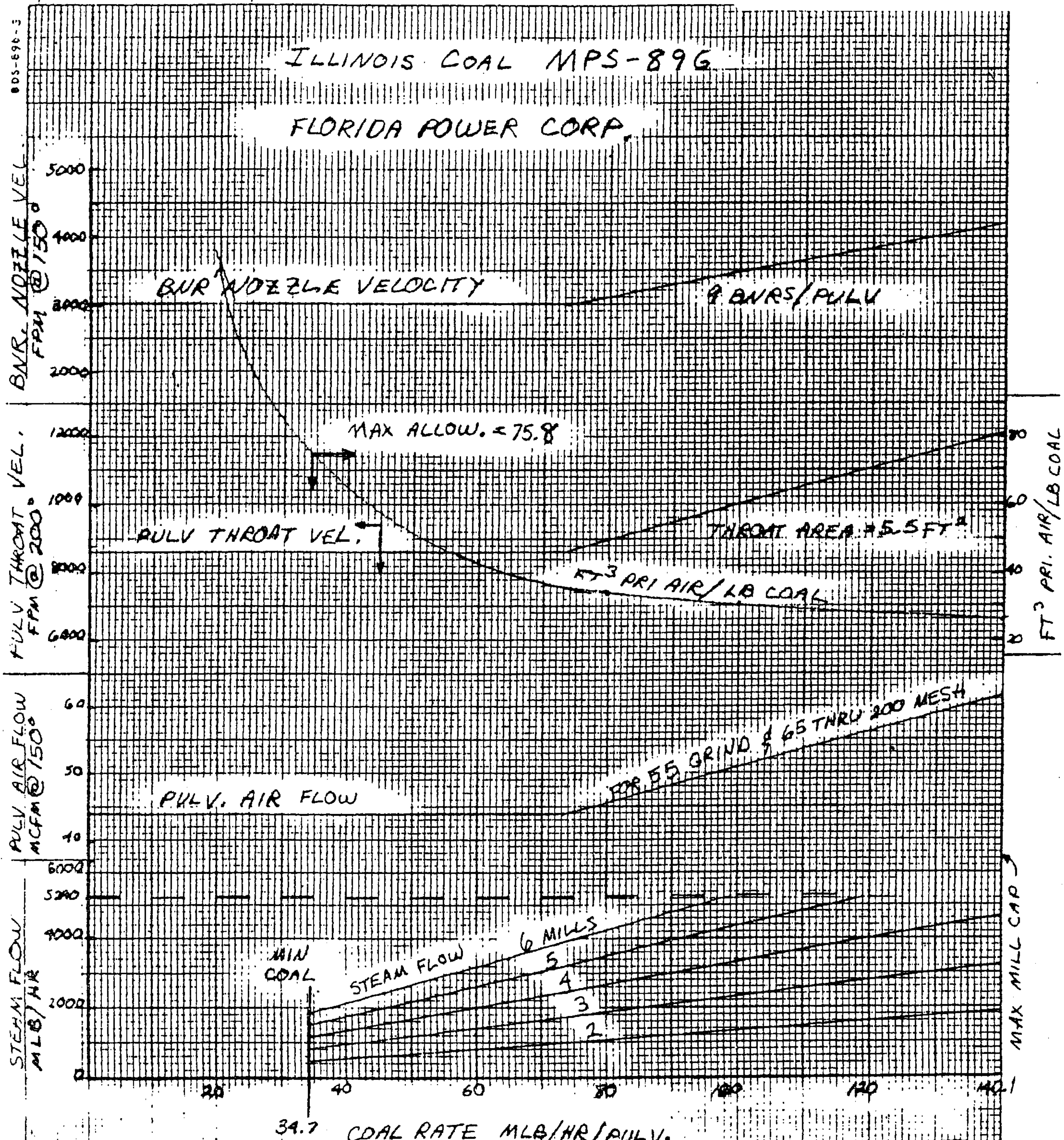
THESE CURVES ARE SUBMITTED FOR THE PURCHASER'S CONVENIENCE AND THE PERFORMANCE INDICATED THEREON SHALL NOT BE OFFERED BY THE COMPANY OR CONSTRUED BY THE PURCHASER AS A PROPOSAL OR CONTRACT OBLIGATION

DRAWN BY	DATE	APPROVED BY	DATE	A. O.
J. NEIDERT	9-26-79	R [signature]	11-14-79	
REL. NO. AND DATE 1(6-12-80)		CODE NO.	COMPONENT NO. 334-0603	CONTRACT NO. RB-603

CIS-101.03

P-

THE BABCOCK & WILCOX COMPANY
CONTRACT INFORMATION SHEET



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DRAWN BY	DATE	APPROVED BY	DATE	A. O.
J. NEIDERT	9-26-79	RBA	11-14-79	
REL. NO. AND DATE 1(6-12-80)	CODE NO. 334-0603	COMPONENT NO.	CONTRACT NO. RB-603	

CIS 101.04

A. FUEL AS FIRED

SAMPLES
ANALYSIS SPECIFIED
50/50 BLEND OF EASTERN & WESTERN

GRINDABILITY	55	42
	ILLINOIS	PERF-BLEND
ASH SOFT. TEMP., F (REDUCING)	1950	
MOISTURE, TOTAL		18.5
VOLATILE MATTER		31.0
FIXED CARBON		42.6
ASH		7.9
TOTAL		100.0

FUEL	EASTERN	WESTERN	ILLINOIS	BLEND
% BY	WT.	WT.	WT.	WT.
ASH	10.00	5.80	13.00	7.90
S	0.05	0.47	4.20	0.49
H_2	4.90	3.40	4.40	3.90
C	69.00	48.50	62.00	58.80
CH_4				
C_2H_4				
C_2H_6				
C_3H_8				
C_4H_{10}				
C_5H_{12}				
C_6H_{14}				
CO				
CO_2				
HCl	0.05	0.02	0.02	0.03
H_2O	7.00	30.00	10.00	18.50
N_2	1.40	0.7	1.38	1.10
O_2	7.65	11.10	5.00	9.28
TOTAL	100.00	100.00	100.00	100.00
BTU/LB	12450	8125	11000	10235
BTU/CU FT AT 60F 30 IN.HG				

H.H. NOT INCLUDING VALVES & STATIC HEAD.

B. PREDICTED PERFORMANCE

STEAM LEAVING SH, K LB/HR	2369	4738	5240	2369	4738	5240
STEAM LEAVING RH, K LB/HR	2064	3960	4345	2064	3960	4345
STEAM LEAVING RH, K LB/HR						
TYPE OF FUEL	ILL	ILL.	ILL.	BLEND	BLEND	BLEND
LOAD CONDITION	CONT-PACL	CONT-GUAR	CONT-MCR	CONT-PACL	CONT-GUAR	CONT-MCR
EXCESS AIR LEAVING ECON., %	35	20	20	35	20	20
NO. OF BURNERS IN OPERATION	45	54	54	45	54	54
HEAT AVAIL., MKB/HR (FUEL & HEATED AIR)	3493	6295	6845	3471	6295	6849
TOTAL INPUT, MKB/HR (FUEL & HT. CREDITS)						
HEAT CREDITS, MKB/HR						
FUEL INPUT, MKB/HR	3334	6014	6533	3345	6049	6585
QUANTITY, K LB/HR: FUEL MLB/HR	303.1	546.7	593.9	325.1	588.1	640.3
FLUE GAS ENTERING AIR HTRS.	3748	6061	6589	3723	6047	6583
AIR TO BURNING EQUIPMENT	3381	5493	5967	3323	5414	5895
AIR HEATER LEAKAGE PRI/SEC	112/239	121/262	125/271	114/238	124/259	127/271
PRESSURE, PSIG: STEAM AT SH OUTLET	2425	2500	2640	2425	2500	2640
STEAM AT RH INLET	240	481	520	240	481	520
STEAM AT RH INLET						
PRESSURE DROP: REHEATER 1	13	23	28	13	23	28
REHEATER 2						
ECONOMIZER **	7	29	39	7	29	39
DRUM TO SH OUTLET	36	145	176	36	145	176
TEMPERATURE, F: STEAM: LEAVING SUPERHEATER	1005	1005	1005	1005	1005	1005
LEAVING REHEATER 1	1005	1005	1005	1005	1005	1005
ENTERING REHEATER 1	529	600	606	529	600	606
LEAVING REHEATER 2						
ENTERING REHEATER 2						
GAS: LEAVING ECONOMIZER	599	671	678	599	671	677
LEAVING AH (EXCL. LKG) PRI/SEC	281/260	283/278	280/279	279/252	279/271	278/275
LEAVING AH (INCL. LKG) PRI/SEC	253/249	259/268	259/270	257/241	263/262	263/264
WATER ENTERING ECONOMIZER	459	535	546	459	535	546
AIR: ENTERING UNIT PRI/SEC	94/81	98/83	100/83	96/81	101/83	102/83
LEAVING AIR HEATER PRI/SEC	545/537	416/586	441/588	539/530	529/582	545/564
RESISTANCE, IN. OF WATER: GAS: FURNACE & CONVECTION BANKS	1.8	3.5	3.9	1.8	3.5	3.9
FLUES TO AH OUTLET	0.5	0.9	1.0	0.5	0.9	1.0
AIR HEATER	1.8	4.0	4.5	1.6	3.5	4.1
TOT. FROM FURN TO AH OUTLET	4.1	8.4	9.4	3.9	7.9	9.0
AIR: FUEL BURNERS & WINDBOX	1.2	3.2	3.7	1.2	3.0	3.4
DUCTS & FLOW METER	1.2	3.5	4.1	1.2	3.2	3.9
AIR HEATER	1.5	3.6	4.2	1.5	3.3	3.9
TOT. FROM AH INLET TO FURN.	3.9	10.3	12.0	3.9	9.5	11.2
HEAT LOSS-EFF., %: DRY GAS	4.50	4.50	4.50	4.13	4.34	4.38
H_2 & H_2O IN FUEL	5.03	5.09	5.07	5.78	5.88	5.88
MOISTURE IN AIR	0.11	0.11	0.11	0.10	0.11	0.11
UNBURNED COMBUSTIBLE	0.30	0.30	0.30	0.3	0.30	0.30
RADIATION	0.10	0.17	0.16	0.3	0.17	0.16
UNACC. FOR & MFRS. MARGIN	1.50	1.50	1.50	1.5	1.50	1.50
TOTAL HEAT LOSS	11.74	11.67	11.66	12.11	12.30	12.33
*GROSS EFFICIENCY OF UNIT, %	88.26	88.33	88.34	87.89	87.70	87.67
HEAT CREDITS ADJUSTMENT, %						
NET EFFICIENCY A.S.M.E. PTC-4.1, %						
FUEL EFFICIENCY, % (OUTPUT/FUEL INPUT)						
PULVERIZERS: NO. IN USE PER BOILER	5	6/5	6/5	5	6/5	6/5
TOTAL POWER, KW HP/ION MOTOR OUTPUT						
% THRU 200 U.S.S. SIEVE	80	75/71	73/69	74	73/67	69/65

PREDICTED PERFORMANCE IS BASED ON COMBUSTION AIR ENTERING UNIT WITH 0.013 LB MOISTURE/LB DRY AIR, ON 29.92 IN. HG. BAROMETRIC PRESSURE, ON CONDITIONS & EQUIPMENT GIVEN ON THIS SUMMARY SHEET & BY ARRANGEMENT SHOWN ON DRAWING 4102 J & CONTRACT DRAWINGS

C. EQUIPMENT PER UNIT

TYPE RADIANT CAROLINA
SIZE RBC 57 29/NB
DESIGN PRESSURE = 2975 PSIG (DRUM & SH)
250 PSIG (RH) 2052 (ECON...)

PRESSURE PART HEATING SURFACE, SQ FT	
FURNACE: WATER COOLED SCREEN (CIRCUMFERENTIAL)	
WATER COOLED (PROJECTED)	48820
SUPERHEATER (CIRCUMFERENTIAL)	
SUPERHEATER (PROJECTED)	45631
TOTAL FURNACE HEATING SURFACE	94451
CONVECTION: SATURATED (CIRCUMFERENTIAL)	10534
SUPERHEATER (CIRCUMFERENTIAL)	144836
REHEATER 1 (CIRCUMFERENTIAL)	240472
REHEATER 2 (CIRCUMFERENTIAL)	
ECONOMIZER	146570
TOTAL CONVECTION HEATING SURFACE	542412
TOTAL FURN. & CONV. PRESSURE PART, HTG. SURF.	636863
FLAT PROJECTED FURNACE HEATING SURFACE	
TO FACE OF PLATENS (24" CENTERS)	22782
TO FACE OF CONVECTION SURFACE (12" CENTERS)	105963
FURNACE VOLUME, CU FT	229334

AIR HEATER: TYPE ROTHEMUHLE REGENERATIVE NO: 1-PRI. 2-SEC.
TOTAL HEATING SURFACE, SQ FT
PRIMARY - SIZE = 10.6 V x 36 HS = 250522
SECONDARY - SIZE = 12.5 V x 68 HS = 824850

FUEL BURNER: TYPE DUAL REGISTER - PULV. COAL
NO. 54

PULVERIZER: TYPE MPS SIZE 89 G NO. 6
CAPACITY OF 5 PULV. IS 5240M LB STEAM/HR BASED ON 48 GRIND
10285 BTU COAL AT 65 % THRU 200 U.S.S. SIEVE BLEND
FOR 128M LB COAL/PULV.-HR AT 65% THRU 200 U.S.S. SIEVE MIN. GRIND
IS 47. MAXIMUM SURFACE MOISTURE IS 19 % REQUIRING 565 F AIR.
TOTAL

STEAM TEMP. CONTROL:
MAIN STEAM BY ATTEMPERATION
REHEAT STEAM BY GAS RECIRC. & ATTEMPERATION

UNIT COMP. STRUCTURE FEATURES:
MEMBRANE WALLS
BALANCED DRAFT
COMPLETE BY-PASS SYSTEM

VARIABLE PRESSURE OPERATION POSSIBLE BELOW 63% of GUAR LOAD.

*CORRESPONDING TO ABR. METHOD PAR. 7.07 A.S.M.E. PTC-4.1

REVISIONS NO.	DESCRIPTION	BY	DATE

FLORIDA POWER CORPORATION.
CRYSTAL RIVER UNIT # 4

UTILITY BOILER PERFORMANCE SUMMARY
BY J.H. APPD. RGD DATE 3-25-80
THE BABCOCK & WILCOX COMPANY
P12-4657-1670-350

PEF-FUEL-003739

FLORIDA POWER CORPORATION
ST. PETERSBURG, FLORIDA

PLANT PERFORMANCE
FOSSIL OPERATIONS

CRYSTAL RIVER UNIT 4
STEAM GENERATOR ACCEPTANCE TEST
SUMMARY REPORT

APRIL, 1983

PREPARED BY: DAVID R. KARP
ENGINEER II
PLANT PERFORMANCE

STEAM GENERATOR ACCEPTANCE TEST

On April 8 and 9, 1983, Plant Performance conducted two acceptance tests on the Babcock and Wilcox Steam Generator at Crystal River Unit 4. The primary intent of this testing effort was to verify the boiler manufacturer's performance related guarantees. The tests were performed with the unit operating as close to design MCR conditions as possible and in accordance with the Operating Instructions No. 20 (OI-20).

In obtaining the boiler efficiency and performance related results, all test data was manipulated according to the procedures outlined within ASME PTC 4.1 Par. 7.3; Efficiency by the Heat Loss Method. All corrections to standard or guarantee conditions were made according to PTC 4.1 Par. 7.5. The guarantee values to which the corrected test results were compared are referenced on the B&W Commercial Summary Sheet, Par. C.6 Pages C-27 through C-34. The uncorrected, "As Tested" results were compared to the test results obtained from the CR4 performance log.

It is the opinion of Plant Performance that the steam generator at CR4 has indeed met B&W performance guarantees; therefore, it is recommended that no additional acceptance testing be performed for steam generator efficiency. The table, on the following page, outlines the test results. Following the table, a brief analysis is presented with the intent of explaining any significant discrepancies.

Karp(SGAT)D183

Losses, %	Babcock and Wilcox Design Guarantees	5-19-83 Corrected Test Results	5-19-83 Uncorrected "As Tested" Results	CR4 Performance Log Results
Dry Gas Loss	4.34	4.41	4.38	4.78
H & H_2O in Fuel Loss	5.89	4.71	4.21	4.17
H_2O in Air Loss	0.11	0.11	0.05	0.11
Unburned C in Ash Loss	0.30	0.22	0.22	0.19
Radiation Loss	0.17	0.17	0.17	0.21
Unaccounted Losses	1.50	1.50	1.50	1.50
Total	12.31	11.12	10.53	10.96
Boiler Efficiency	87.69	88.88	89.47	89.12
Coal HHV, BTU/LB	10285	12822	12822	12721

The "corrected" boiler efficiency test results compare 1.19 percentage points better than design. The difference is accounted for by the loss associated with the moisture created from the combustion of hydrogen and the moisture in the "As fired" fuel. Basically, the difference between results was a function of the coal higher heating values used in the analysis.

The "uncorrected" boiler efficiency test results compare 0.35 percentage points better than the CR4 performance log results. The difference here is accounted for by the dry gas losses. This can be explained by a slightly larger temperature differential (between inlet air and exit gas temperatures) used in the CR4 performance log calculations.

In addition to acceptance testing, baseline testing was also performed. The figure on the following page contains baseline and acceptance test results.

FLORIDA POWER CORPORATION
SYSTEM ANALYSIS
PROJECT FILE 7645.41.0601.22

COAL HANDLING

BLACK & VEATCH/consulting engineers

7/15/80

	SYSTEM ANALYSIS	FILE NO. 7645.41.0601.22	
	COAL HANDLING	PAGE 0 OF 22	REV 0

PROJECT NAME: Florida Power Corporation, Crystal River 4

PROJECT NO.: 7645

REV	PREPARED BY	DATE	REVIEWED BY	DATE	APPROVED BY	DATE
A	G.L. Watts	2-6-78	R.L. Hollrah	2/6/78		
	E.K. Leclair		G.L. Christensen	2/6/78		
0	T. N. Birkett	TNB 6-5-80	J. W. Fitzwater	7/7/80	R. L. Hollrah	7/15/80
	D. T. Roush	7-1-80	G. L. Christensen	7/15/80	R. G. Ruisch	7/15/80

REV	LIST OF REVISED PAGES

N-179A

FLORIDA POWER CORPORATION
COAL HANDLING

TABLE OF CONTENTS

LIST OF FIGURES AND TABLE

FPC-7/15/80

P-GN-180B

FOREWORD

Based upon the information presented in this analysis and other considerations developed in discussions between Florida Power Corporation and Black & Veatch, the conclusions stated in this analysis have been adopted for the design of the Crystal River Plant with the following clarification.

(1) Coal supply will be from Units 1 and 2 coal handling system; therefore, emergency stockout facilities inside the railroad loop are not required.

FLORIDA POWER CORPORATION
SYSTEM ANALYSIS
PROJECT FILE 7645.41.0601.22

COAL HANDLING

1.0 INTRODUCTION

The Florida Power Corporation has proposed to construct two 670 MW coal-fired units at the existing Crystal River Station. The objective of this analysis is to determine the optimum coal handling system for these units and to describe the basic design parameters, operational procedures, and major components thereof.

2.0 SUMMARY

2.1 SUMMARY OF IMPORTANT INFORMATION

(1) The Units 4 and 5 stockout and reclaim system will receive coal from the existing barge unloading and railcar unloading facilities. The new system will interface with the existing system for Units 1 and 2.

(2) The stockout and reclaim system will provide for the handling, storage, and blending of at least two types of coal. Complete segregation of the two coals is required.

(3) Approximately 855,000 tons of reserve storage will be provided for 90 days fuel requirements for both units operating at 60 per cent capacity.

(4) The stockout and reclaim system will provide 43,000 tons of active storage for 3 days fuel requirements for both units operating at 90 per cent capacity.

(5) The maximum design burn rate for Units 4 and 5 is 330 tons per hour per unit or 660 tons per hour total, based on a design coal heating value of 10,285 Btu per pound.

(6) The coal silo storage for Units 4 and 5 will provide for 8 hours operation for each unit based on the maximum design burn rate.

(7) The general arrangement of the coal handling system will be as follows; from the barge and rail unloading points at Units 1 and 2 a conveyor system will be added to and modified to converge with a single 2,500 tph belt conveyor system which will convey the coal to the north coal yard, where the active and reserve storage piles will be located.

Dual 800 tph conveyors will transport the coal from the north coal yard to the Coal Crusher Building which will have redundant 800 tph crushers. Crushed material will be directed to dual 800 tph conveyors feeding Plant Surge Hopper No. 2 located at the units.

P-GN-180B

Coal discharged from Plant Surge Hopper No. 2 will be directed to one of two 400 tph transfer conveyors provided with each unit, feeding a series of 400 tph cascade conveyors.

(8) Three plans were considered for the active storage equipment associated with this system. Costs for the alternate plans are presented below.

Comparative Costs	Plan A Dual Stacker/ Reclaimers	Plan B Traveling Stacker	Plan C Traveling Tripper
	$1,000	$1,000	$1,000
Total differential capital cost	Base	3,646	3,328

(9) The trencher type stacker/reclaimers of Plan A can be remotely operated from a control room at the Coal Crusher Building. If operators were required for the machines, operating costs would be equivalent to $2,960,000 in capital costs.

2.2 CONCLUSIONS

The coal handling system should be provided with dual trencher type stacker/reclaimers arranged generally as shown on Figures 3-3 and 3-4 (Plan A). Remote operation should be provided for the stockout and reclaim system including the stacker/reclaimers from an elevated control room in Crusher Building No. 2. No operators are required on the trencher type stacker/reclaimers.

If coal from Units 1 and 2 can be used for emergencies, then the area within the coal loop will not be needed for emergency coal storage.

P-GN-180B

3.0 ANALYSIS
COAL HANDLING SYSTEM

3.1 OBJECTIVE

The objective of this analysis is to determine the optimum coal handling system for Units 4 and 5 at the Crystal River Plant site.

3.2 REQUIREMENTS

The requirements of the system are as outlined below.

(1) The Units 4 and 5 stockout and reclaim system will receive coal from the existing barge unloading and railcar unloading facilities.

(2) Approximately 50 per cent of the coal required for Units 4 and 5 will be delivered to the plant site in 70 car unit trains consisting of 100-ton capacity cars. An average of four to six trains per week will be required to supply this amount assuming the present projections for plant capacity. Maximum unloading rate for this equipment is 2,500 tph.

The remaining 50 per cent of coal required for Units 4 and 5 will be transported to the plant site in ocean-going barges. The existing coal receiving facilities at the Crystal River Plant are designed for unloading barges with up to 13,000 short tons capacity. Based on Western coal, an average of about three barges per week will be required. The barge unloading system is designed for unloading at 1,500 tph maximum; however, field reports indicate that the average unloading rate is approximately 700 tph.

(3) The stockout and reclaim system will provide for the handling, storage, and blending of at least two types of coal. Complete segregation of the two coals is required prior to blending.

(4) Approximately 855,000 tons of reserve storage will be provided for 90 days fuel requirements for both units operating at 60 per cent capacity. This is to preclude unit downtime in the event of an interruption in coal supplies.

(5) The stockout and reclaim system will provide 43,000 tons of active storage for 3 days fuel requirements for both units operating at 90 per cent capacity. Coal reclaimable by mobile equipment will not be considered as active storage.

(6) The maximum design burn rate for Units 4 and 5 is 330 tons per hour per unit or 660 tons per hour total, based on a design coal heating value of 10,285 Btu per pound.

(7) The coal silos for Units 4 and 5 will provide for 8 hours operation for each unit based on the maximum design burn rate.

(8) The coal crushing and silo fill system will provide for 100 per cent redundancy for all conveying and crushing equipment.

(9) All costs shown in the analysis shall include 20.5 per cent interest during construction and 8.7 per cent general indirect construction costs. All costs are 1982 costs.

3.3 SYSTEM DESCRIPTION

All plans considered in this analysis employ the same general plan arrangement as shown on Figure 3-1. Coal will be received by modifications and addition of equipment now serving Units 1 and 2. Coal is currently received at an existing barge dock and an existing railcar unloader.

Barge coal received at Transfer Point No. 1 will be conveyed by a modified Conveyor No. 2. Transfer Point No. 2 will divert the coal to an existing Conveyor No. 3-A, serving Units 1 and 2, or onto Conveyor No. 3-B. An additional transfer at Transfer Point No. 3 will receive coal from Conveyor No. 3-B and transfer it onto Conveyor No. 29 to a new Transfer Point No. 24.

Rail coal will be unloaded by the existing train unloader and conveyed to new Transfer Point No. 23 by modified Conveyor No. 11. Coal then may be diverted to the existing radial stacker or to converge with barge coal at Transfer Point No. 24.

Barge and rail coal received by Transfer Point No. 24 will be transferred by a 2,500 tph conveyor, Conveyor No. 30, to Transfer Point No. 25,

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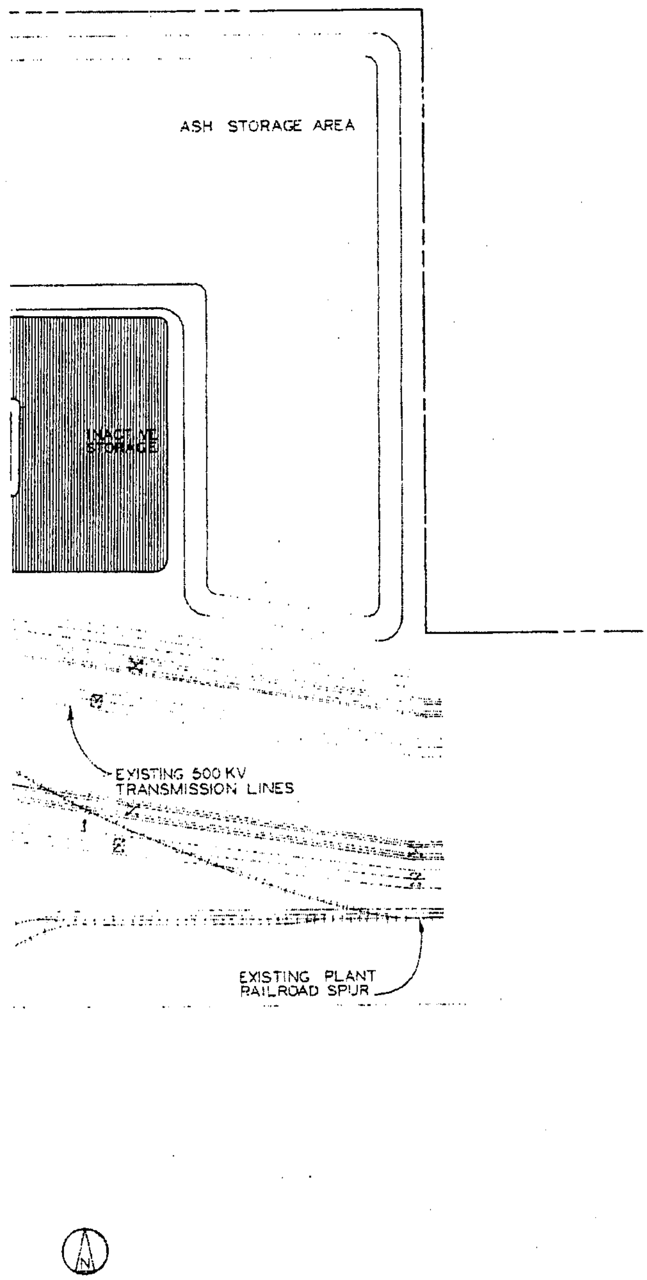


GENERAL PLAN
ARRANGEMENT
FIGURE 3-1

located inside the railroad loop. At this point, the coal will be transferred to Conveyor No. 31, also 2,500 tph, and transferred to the north coal yard.

The general base plan has Conveyor No. 24 passing through a tunnel which will be constructed under the railroad track. The tunnel construction would require a curtailment of rail coal deliveries, which could be feasible if downtime was properly coordinated with plant operation and downtime is kept to a minimum.

The advantage of the general base plan is that the space within the railroad loop would be accessible by the conveyor system for emergency coal stockout and storage at a future date if required.

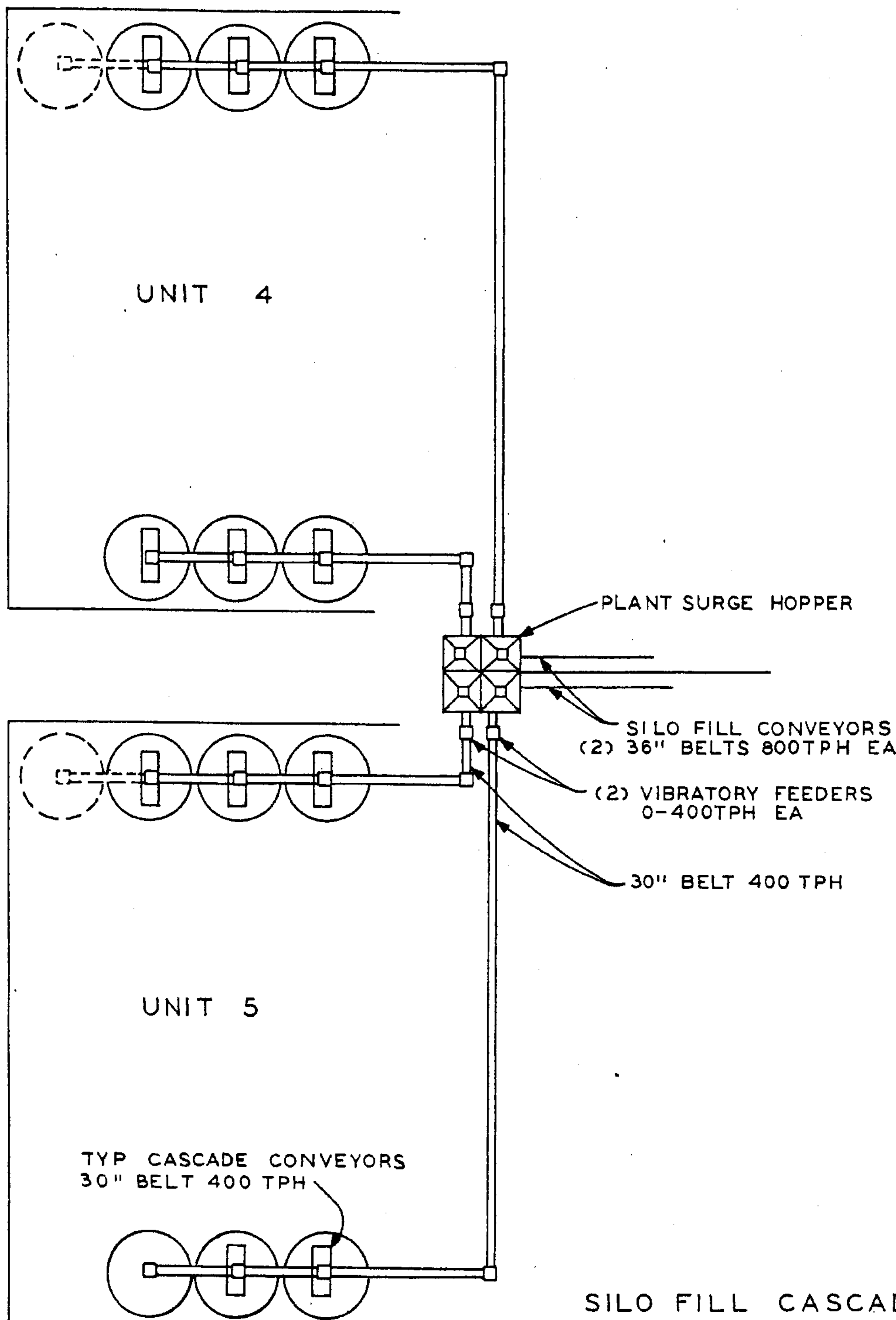
In the northeast area, coal arriving at Transfer Point No. 26 may be diverted to active storage on Conveyor No. 32 or to Transfer Point No. 27 on Conveyor No. 33, both 2,500 tph conveyors. In a like manner, at Transfer Point No. 27 coal may be diverted to active storage on Conveyor No. 34 or to dual 800 tph conveyors to Units 4 and 5 Coal Crusher House No. 2.

Each of the two crushers will have the capability of discharging crushed or internally bypassed material onto two 800 tph conveyors, which will transport and elevate the coal to a common surge hopper.

The Plant Surge Hopper No. 2 will have four outlets, with a working capacity of 180 tons and a receive and discharge rate of 1,600 tph. Coal is discharged through each outlet onto a vibratory feeder and then to a 400 tph transfer conveyor. The cascade conveyors, shown on Figure 3-2, receive the coal from the transfer conveyors. The cascade conveyor system was chosen over other silo filling systems due to its reliability, simple controls, and low cost.

The transfer of coal into the silos will be accomplished by the first cascade conveyor discharging into the first silo of the series until that silo is filled and then discharging to the next conveyor in sequence. The feed of coal from one cascade conveyor to the next will be accomplished by positioning diversion gates. The progressive filling and subsequent transfer action will continue through all conveyors and silos of that row until all the silos are filled. All cascade conveyors will be rated at 400 tph.

		FILE NO. 7645.41.0601.22	
	SYSTEM ANALYSIS		
	COAL HANDLING	PAGE 10 OF 22	REV 0



SILO FILL CASCADE
CONVEYOR SYSTEM

FIGURE 3-2

P-GN-180B

FPC-7/15/80

Section 2A - DESIGN CRITERIA

2A.1 GENERAL. This section covers the design, construction, and functional criteria for the coal conveying system dust collectors to be furnished under these specifications.

* 2A.2 CODE REQUIREMENTS. All equipment and materials furnished under these specifications shall be designed and constructed in accordance with the latest applicable requirements of the standard specifications and codes of ANSI, NFPA, ASME, ASTM, NEMA, IEEE, EEI, AISC, AWS, SAE, NAAMM, NEC, AGMA, CEMA, AMCA, IGCI, ACGIH, and other such regular published and acceptable standards, except where modified or supplemented by these specifications; and in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards." Any conflicts between
** standards shall be referred to the Engineer who will determine which standard shall govern.
Contractor

2A.3 TYPE. Coal conveying system dust collectors shall be induced draft, filter bag units, enclosed in stiffened plate housings and supported on wide flange column legs, complete with drilled baseplates and sway bracing. Baseplates shall rest on foundations or structures furnished under separate specifications.

Dust laden air shall be directed to the Contractor's inlet plenum at the dust collector units through ductwork furnished under these specifications. After passing through the filter bags, the filtered air shall be
*** drawn from the units by fans. Fan discharge ducts shall be furnished under these specifications.

Dust collected by the filter bags, as well as dust precipitated within the unit, shall fall into hoppers which shall form the unit housing bottoms. The final discharge area shall be sufficiently sized to accommodate the maximum dust volume discharged during the unit purge cycle. A screw conveyor for each hopper, or row of hoppers, shall convey the dust from the hopper bottoms. A rotary vane type air lock valve shall be furnished at each point where hopper-collected dust is to be transferred from the vacuum condition in the collectors to a higher pressure region.

Baghouse inlet and discharge points shall be arranged to allow a minimum of coal dust entrainment. Discharge points shall be located to prevent turbulence of the collected dust beyond the area of collection of the collectors.

2A.4 ARRANGEMENT. Arrangement of the coal handling system dust collectors shall be as indicated on the Engineer's drawings listed herein.

*** The dimensions indicated on the drawings indicate the maximum available space for each dust collector. No additional space is available for bag removal.

*Refer to Contractor's proposal pages B-8(C) and B-8(D).
**Revised in accordance with Contractor's proposal page B-8(D).
***Refer to Contractor's proposal page B-8(D).

2A.5 DRAWINGS. Arrangement of the coal conveying system dust collectors shall be as indicated on the following drawings included with these specifications.

Drawing No.	Rev	Title
S-7645-081678-1.0	0	COAL CONVEYING SYSTEM FLOW DIAGRAM - BASE BID
S-7645-081678-1.1	0	COAL CONVEYING SYSTEM FLOW DIAGRAM - OPTION 1
S-7645-081678-1.2	1	COAL CONVEYING SYSTEM FLOW DIAGRAM - OPTION 2
S-7645-081678-2.0	0	COAL CONVEYING SYSTEM PLOT PLAN - BASE BID
S-7645-081678-2.1	0	COAL CONVEYING SYSTEM PLOT PLAN - OPTION 1
S-7645-081678-2.2	0	COAL CONVEYING SYSTEM PLOT PLAN - OPTION 2
S-7645-081678-4	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 1, AND CONVEYOR NO.'S 2 & 1 EXTENDED
S-7645-081678-5	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 2
S-7645-081678-8	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 23
S-7645-081678-10	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 24
S-7645-081678-13	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 25
S-7645-081678-15	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 26
S-7645-081678-18	0	COAL CONVEYING SYSTEM TRANSFER POINT NO. 27
S-7645-081678-20	1	COAL CONVEYING SYSTEM COAL CRUSHER BUILDING NO. 2, ELEVATIONS
S-7645-081678-21	0	COAL CONVEYING SYSTEM COAL CRUSHER BUILDING NO. 2, FLOOR PLANS

Drawing No.	Rev	Title
S-7645-081678-23	0	COAL CONVEYING SYSTEM PLAN SILO FILL SYSTEM
S-7645-081678-24	0	COAL CONVEYING SYSTEM PLANT SURGE HOPPER NO. 2
S-7645-081678-26	0	COAL CONVEYING SYSTEM CASCADE CONVEYOR NO. 403
S-7645-081678-27	0	COAL CONVEYING SYSTEM CASCADE CONVEYOR NO. 404
S-7645-081678-28	0	COAL CONVEYING SYSTEM CASCADE CONVEYOR NO. 503
S-7645-081678-29	0	COAL CONVEYING SYSTEM CASCADE CONVEYOR NO. 504
S-7645-081678-30	0	COAL CONVEYING SYSTEM TYPICAL CONVEYING EQUIPMENT DETAILS
S-7645-081678-31	0	COAL CONVEYING SYSTEM TYPICAL CONVEYING EQUIPMENT DETAILS
A1009	F	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 233'-9"
A1010	E	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 244'-0"
A1011	E	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 253'-6"
A1012	E	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 265'-0"
A1013	E	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 274'-6"
A1014	E	PLANT ARRANGEMENT SOOT BLOWER PLATFORM EL 276'-6", EL 278'-0", & EL 283'-6"
S5060	1	STEEL FRAMING - STEAM GENERATOR AREA SOOT BLOWER PLATFORM EL 253'-6"
S5061	1	STEEL FRAMING - STEAM GENERATOR AREA SOOT BLOWER PLATFORM EL 265'-0"

Drawing No.	Rev	Title
S5062	1	STEEL FRAMING - STEAM GENERATOR AREA SOOT BLOWER PLATFORM EL 274'-6"
S5063	1	STEEL FRAMING - STEAM GENERATOR AREA SOOT BLOWER PLATFORM EL 276'-6"
S5120	2	STEEL FRAMING - STEAM GENERATOR AREA GIRTS AND COLUMN BRACING - COLUMN ROW 401
S5125	3	STEEL FRAMING - STEAM GENERATOR AREA GIRTS AND COLUMN BRACING - COLUMN ROW 408

2A.6 OPERATIONAL REQUIREMENTS. Dust collectors shall be designed to operate at an efficiency of not less than 99.9 per cent by weight with the conditions specified herein and while operating at the following specified minimum airflow rates. The pressure drop allowances specified below are for bidding purposes only. Actual pressure drops shall be determined by the Contractor based on his final ductwork design.

	Collector Flow Rate ("A" Value for Exhaust Fan Sizing) scfm	Pressure Drop Allowance for Collection Duct and Fan Discharge ("F" Value for Exhaust Fan Sizing) in. of water	Option Number
Dust Collector No. 1	7,525	4.0	Base
Dust Collector No. 2	13,800	4.0	Base
Dust Collector No. 23-1	14,325	5.2	1
Dust Collector No. 23-2	8,300	5.1	Base
Dust Collector No. 24-1	10,400	4.8	Base
Dust Collector No. 24-2	15,075	4.3	1
Dust Collector No. 25-1	8,225	3.3	Base
Dust Collector No. 25-2	8,225	3.3	2

	Collector Flow Rate ("A" Value for Exhaust Fan Sizing) scfm	Pressure Drop Allowance for Collection Duct and Fan Discharge ("F" Value for Exhaust Fan Sizing) in. of water	Option Number
Dust Collector No. 26-1	16,825	4.8	Base
Dust Collector No. 26-2	9,450	4.2	2
Dust Collector No. 27-1	12,600	5.2	Base
* Dust Collector No. 27-2	4,975 5,350	3.9	2
* Coal Crusher Building Dust Collector	12,550 13,600	6.0	Base
Dust Collector No. 403	16,250	5.4	Base
Dust Collector No. 404	21,700	5.2	Base
Dust Collector No. 503	16,250	5.4	Unit 5
Dust Collector No. 504	16,250	5.4	Unit 5

All dust collectors shall be interlocked with the belts from which dust is collected. Accumulated dust shall be conveyed to an appropriate belt moving out from each transfer point, head chute, or bucket elevator generally as indicated on the various drawings. Dust collection at Transfer Point No. 3 will be under a future contract.

Dust Collector No. 1 will collect dust from the head end of Conveyor No. 1, the tail end of Conveyor No. 2 and the front loading skirt of Conveyor No. 2. Dust will be returned to the head chute of Conveyor No. 1.

Dust Collector No. 2 will collect dust from the head end of Conveyor No. 2, the tail ends of Conveyor No.'s 3-1 and 3-2, and the front loading skirts of Conveyor No.'s 3-1 and 3-2. Dust will be returned to the head chute of Conveyor No. 2.

*Revised in accordance with Contractor's proposal page B-8(D).

Dust Collector No. 23-1 will collect dust from the head ends of Conveyor No.'s 24 and 28, the tail ends of Conveyor No.'s 30 (or 30-1 and 30-2 if Option 2 is accepted) and 23, and the front loading skirt of Conveyor No. 23. Dust will be returned to the head chute of Conveyor No. 28.

Dust Collector No. 23-2 will collect dust from the head chute of Conveyor No. 29 and the front load skirt of Conveyor No. 30 (or 30-1 and 30-2 if Option 2 is accepted). Dust will be returned to the head chute of Conveyor No. 29.

Dust Collector No. 24-1 will collect dust from the head end of Conveyor No. 27, the tail end and front loading skirt of Conveyor No. 29, and the Sample Reject Bucket Elevator. Dust will be returned to the Sample Reject Bucket Elevator.

Dust Collector No. 24-2 will collect dust from the head ends of Conveyor No.'s 25 and 27, the tail ends of Conveyor No.'s 26 and 28, and the front loading skirt of Conveyor No. 28. Dust will be returned to head chute of Conveyor No. 28. The ductwork outside the dust hood at the head end of Conveyor No. 27 shall be arranged with remote controlled dampers such that either Dust Collector No. 24-1 or 24-2 can collect dust through it.

Dust collector No. 25-1 will collect dust from the head end of Conveyor No. 30 (30-1), and the tail end and front load skirt of Conveyor No. 31 (31-1). The dust will be returned to the head chute of Conveyor No. 30 (30-1).

Dust Collector No. 25-2 will collect dust from the head end of Conveyor No. 30-2, and tail end and front load skirt of Conveyor No. 31-2. Dust will be returned to the head chute of Conveyor No. 31-2.

Dust Collector No. 26-1 will collect dust from the head end of Conveyor No. 31 (31-1), the tail end and front load skirt of Conveyor No. 33 (33-1) and the head end of Conveyor No. 32. Dust will be returned to head chute of Conveyor No. 31 (31-1). Flexible ducting shall be provided on Conveyor No. 32 to enable the retractable loading skirt to function.

Dust Collector No. 26-2 will collect dust from the head end of Conveyor No. 31-2, and the tail end and front load skirt of Conveyor No. 33-2. The dust will be returned to the head chute of Conveyor No. 31-2.

Dust Collector No. 27-1 will collect dust from the head end of Conveyor No. 33 (33-1), the tail end and front load skirt of Conveyor No. 35-1 (or 35-1 and 35-2 if Option 2 is not accepted) and the head end of Conveyor No. 34. Dust will be returned to the head chute of Conveyor No. 33 (33-1). Flexible ducting shall be provided on Conveyor No. 34 to enable the retractable loading skirt to function.

Dust Collector No. 27-2 will collect dust from the head end of Conveyor No. 33-2, and the tail end and front loading skirt of Conveyor No. 35-2. Dust will be returned to the head chute of Conveyor No. 33-2.

The Crusher Building Dust Collector will collect dust from the head ends of Conveyor No.'s 35-1 and 35-2, the tail ends and front loading skirts of Conveyor No.'s 36-1 and 36-2, the Coal Crusher Hopper No. 2, and Crusher Feeder No.'s 3 and 4. Dust will be returned to Coal Crusher Hopper No. 2.

Dust Collector No. 403 will collect dust from the head ends of Conveyor No. 401; the tail end, all head chutes, and all loading skirts of Conveyor No. 403; and Silo No.'s 402, 403, and 404. Dust will be returned to either Silo No. 402 or 403. *

Dust Collector No. 404 will collect dust from the head ends of Conveyor No.'s 36-1 and 36-2; Plant Surge Hopper No. 2; Plant Surge Hopper Feeder No.'s 401, 402 and optional Plant Surge Feeder No.'s 501 and 502; Silo No.'s 405, 406 and 407; the tail end, all head chutes, and all loading skirts of Conveyor No. 404; the tail end and load skirts of Conveyor No. 401; and Unit 5 Option Conveyor No.'s 501 and 502. Dust will be returned to either Silo No. 405 or 406. *

Dust Collector No. 503 will collect dust from Silo No.'s 502, 503, and 504; the head end of Conveyor No. 501; and the tail end, all head chutes, and all loading skirts of Conveyor No. 503. Dust will be returned to either Silo No. 502 or 503. *

Dust Collector No. 504 will collect dust from Silo No.'s 505, 506, 507; the head end of Conveyor No. 502; and the tail end, all head chutes, and all loading skirts of Conveyor No. 504. Dust will be returned to either Silo No. 505 or 506.

2A.7 DESIGN CONDITIONS. Dust collectors shall be designed for the operating conditions specified herein.

2A.7.1 Plant Elevation. The plant site is approximately 11 feet above mean sea level.

2A.7.2 Design Pressure. Inlet plenum, housing, outlet duct to exhaust fan, and any other components subjected to the operating pressures of the dust collecting units shall be designed for an operating differential pressure of plus or minus 20 inches of water. **

2A.7.3 Ambient Conditions. Consideration shall be given to the range of ambient temperature and relative humidity. Particular attention shall be given to design for salt air atmosphere.

The dust collectors will be located in unenclosed structures and will be subjected to inclement weather conditions, except for dust collectors located within the Generation Building. The unenclosed dust collectors may in the future be located in enclosed areas.

*Refer to page 3 of Contractor's letter dated June 23, 1979.
**Revised in accordance with Contractor's proposal page B-8(D).

All equipment shall be designed to operate in, and shall be sized for, the following ambient conditions.

Location	Temperature, F
Transfer Point No.'s 1, 2, 23, 24, 25, 26, and 27	+15 to +105
Coal Crusher Building No. 2	+15 to +105
Coal silos	+35 to +120

2A.7.4 Coal Data. The coal received by the coal conveying equipment will be Eastern bituminous coal or Western subbituminous coal. The coal can be saturated with surface moisture, and will be normally 3" x 0" size up to the crusher building and 1-1/2" x 0" size thereafter.

Coal downstream of Transfer Point No. 27 will be a blend of coals.

A tabulation of eight coal sources and eight blends, on a 50/50 weight basis, has been included at the end of this Section 2A.

Coal dust shall be considered to weigh 50 pounds per cubic foot for calculation of capacities, and 70 pounds per cubic foot for structural load calculations.

2A.7.5 Exhaust Air and Dust Conditions. Equipment and materials furnished shall be designed to operate under the dust conditions and levels specified herein.

Each dust collector shall be designed to handle air laden with coal dust of the following average concentration and properties.

Dust concentration in air, grains per acfm	13
Approximate percentage by weight of particles 10 microns and smaller	90

2A.8 STRUCTURAL DESIGN CRITERIA. Structural design conditions for the dust collection system shall be as specified herein.

2A.8.1 Wind Loads. Wind loads shall be based on ANSI Standard A58.1-1972. Basic wind speed shall be 110 miles per hour as determined from Figure 2 of the standard entitled "Annual Extreme Fastest-Mile Speed 30 Feet Above Ground, 100 Year Mean Recurrence Interval," and interpolated from Table 5, Exposure C. A step function of pressure with height may be used. A minimum loading of 25 psf shall be used.

2A.8.2 Seismic Loads. Effects of seismic loads on the design of all structures shall be given full consideration.

These design considerations shall be submitted to, and shall be acceptable to, the Engineer and the Company.

Seismic analysis and design shall be in accordance with the requirements for construction of equipment located in ANSI Standard A58.1-1972 Risk Zone 1.

2A.9 MECHANICAL DESIGN CRITERIA. Mechanical design criteria for the dust collection system shall be as specified herein.

2A.9.1 Exhaust Fan Sizing. Fans shall be sized to provide the specified airflow under normal continuous operation of the dust collectors with dust laden air as specified herein. Fan sizing shall not be less than that determined by use of values for volume and static pressure calculated by the following equations.

Volume = 1.15 x A

Static pressure = B+C+D+E+F

Symbols in the above equations represent the following.

A = Specified collector airflow rate

B = Entrance loss at Contractor's plenum with volume equal to 1.15A

C = Pressure drop from inlet plenum to exhaust fan inlet with volume equal to 1.15A under normal filter bag conditions

D = Fan discharge velocity head

E = Allowance for inlet vane control flexibility (use 1.5 inches of water)

F = Allowance for inlet collection duct and fan discharge. Values for "F" shall be as specified herein under OPERATIONAL REQUIREMENTS.

Ambient air conditions used for fan sizing shall be as specified herein under DESIGN CONDITIONS.

Values of factors and terms used in the calculations of minimum required fan sizes in accordance with the above criteria shall be listed in the spaces provided in Equipment Data in Section C.

2A.9.2 Fan Motor Sizing. Each exhaust fan motor shall be sized in accordance with Article 1D.4. Maximum load horsepower shall be taken as the fan horsepower corresponding to a volume of 1.15A, at a pressure comprised of the sum of Items B, C, D, E, and F as defined herein under Exhaust Fan Sizing, while handling air at the temperatures specified herein under DESIGN CONDITIONS.

2A.9.3 Filter Surface Requirements. Units shall be equipped with filter bags of sufficient number and size to provide the following net air-to-cloth ratios.

Net air-to-cloth ratio will be defined as the actual air flow rates divided by the cloth area actually collecting dust at any time during collector operation; particularly during the filter cleaning process.

Filter Cleaning Mechanism	Air/Cloth Ratio scfm/ft^2
Impulse air jet reverse airflow	7:1
Low pressure reverse airflow	6:1

2A.9.4 Air Compressor Sizing. Each air compressor, air receiver, and control arrangement shall be sized to provide air at the quantity and pressure required.

2A.10 GUARANTEES. Coal handling system dust collectors and accessories shall be guaranteed to perform as specified with the materials and under the conditions specified heretofore.

*Coal handling system dust collectors and accessories shall additionally be guaranteed to be in compliance with all applicable regulatory requirements in force at the time of start-up.

2A.11 TEST PORTS. Test ports shall be provided in the inlet and outlet ductwork of all dust collectors. These ports shall be suitable for the performance of tests as outlined in the latest revisions of the EPA "Test Procedures for Determining Compliance with New Source Performance Standards, Method 5 - Determination of Particulate Emissions from Stationary Sources" as contained in Volume 43, Federal Register.

2A.12 TESTS. The Company will make operational acceptance tests after ** installation of the equipment. Tests will be conducted at approximately the design conditions specified herein, and proper corrections will be made in the calculation of results to account for any variations from the specified design conditions.

If the equipment fails to meet the guarantees, the Contractor shall initiate action to remedy such defects in accordance with the procedures stated in GENERAL CONDITIONS.

*** (ADD NEW PARAGRAPH)

*Refer to pages 1 and 2 of Contractor's letter dated July 12, 1979.
**Revised in accordance with Contractor's proposal page B-8(F).
***Refer to Contractor's proposal page B-8(F)

The bidder's Proposal shall include lump sum price deductions for furnishing 460 volt motors in lieu of the 4000 volt motors specified for Conveyor No.'s 27 and 30 (30-1 and 30-2), and for furnishing 4000 volt motors in lieu of the 6600 volt motors specified for Conveyor No. 31 (31-1 and 31-2) and Crusher No.'s 3 and 4. Price deductions shall be stated separately for each motor.

2A.7 DUST ABATEMENT. The elimination of dust resulting from the coal conveying equipment shall be of paramount importance. The equipment, spouts, chutes, hoppers, and conveyors shall be constructed so that the operation of the system will be essentially dustless. Provision shall be made at all loading, discharge, and transfer points for complete enclosure by dusttight hoods, housings, or casings. The handbook, "Industrial Ventilation," published by the American Conference of Governmental Industrial Hygienists, P.O. Box 453, Lansing, Michigan, shall be used as a guide in designing the enclosures.

The Engineer will submit to the Contractor, the location of each dust evacuation nozzle. The construction of each enclosure at the locations for the nozzles shall be suitable for the subsequent installation of such nozzles.

The use of water sprays and wetting agents for dust control is not contemplated.

* 2A.8 GUARANTEES. The equipment and the appurtenant accessories specified in the following sections shall be guaranteed to perform as specified with the coal, and under the conditions, specified herein. The guaranteed performance shall not be limited by ambient temperature or prolonged precipitation. Design margins shall be incorporated to ensure that specified performance is accomplished on a routine basis.

* Refer to page 5-2 of Contractor's Clarifications and Interpretations.

Docket No. 060658-EI
PEF RFQ for Conveyors
Exhibit No. ____ (JAB-13)
Page 1 of 1

TABLE 1. FLORIDA POWER CORPORATION PERFORMANCE COALS WEIGHT BLENDS-50/50 BASIS

Type Coal	1 & 2	1 & 6	1 & 7	2 & 4	2 & 6	2 & 7	6 & 7	7 & 8
Moisture, %	7.0	11.0	18.5	14.5	11.0	18.5	22.5	18.5
Volatile Matter, %	34.9	32.7	31.0	36.1	37.6	36.0	33.7	33.0
Fixed Carbon, %	49.1	45.9	42.6	42.4	42.0	38.6	35.5	41.5
Ash, %	9.0	10.4	7.9	7.0	9.4	6.9	8.3	7.0
Carbon, %	69.1	62.3	58.8	62.1	62.4	58.8	52.1	58.5
Hydrogen, %	4.7	4.3	3.9	4.5	4.6	4.2	3.7	4.2
Nitrogen, %	1.4	1.2	1.1	1.1	1.2	1.1	0.9	1.1
Chlorine, %	0.05	0.03	0.03	0.05	0.03	0.03	0.02	0.02
Sulfur, %	0.60	0.55	0.49	0.60	0.65	0.59	0.54	0.54
Oxygen, %	8.15	10.22	9.28	9.95	10.72	9.88	11.94	10.14
Gross Calorific Value, Btu/lb	12,225	11,075	10,285	10,825	10,850	10,060	8,910	10,310
Hardgrove Grindability Index	45	45	48	47	45	48	48	47
Ash Analysis, %								
SiO_2	46.0	49.0	40.2	48.4	50.9	40.7	44.3	43.5
Al_2O_3	23.3	23.3	18.2	19.8	22.5	17.8	18.1	23.2
TiO_2	1.0	1.0	1.0	0.8	1.0	1.1	1.0	1.0
Fe_2O_3	7.0	6.6	7.1	6.3	5.6	5.9	5.7	5.0
CaO	10.5	7.1	15.3	9.5	6.8	15.2	11.8	10.5
MgO	1.5	1.7	3.7	2.6	1.2	3.4	2.6	3.7
Na_2O	2.28	1.31	1.50	2.48	3.01	3.67	2.38	1.5
K_2O	1.01	1.28	1.20	0.43	0.82	0.60	0.96	1.7
SO_3	6.1	6.2	9.3	8.1	6.3	9.9	9.8	7.0
P_2O_5	0.44	0.24	1.1	0.55	0.28	1.24	1.00	1.0

Section 2I - COAL SILO UNLOADING CONVEYORS

Screw Conveyor Corporation.

* 2I.1 GENERAL. Two portable self-contained screw conveyors shall be furnished for emergency unloading of coal from silos under the Base Bid, and one optional screw conveyor shall be furnished for Unit 5. One conveyor will be used to unload Coal Silo No. 405 and the other conveyors will unload Coal Silo No.'s 502 and 505 (Unit 5 Option). The conveyors shall be comprised of steel troughs and screw devices, TEFC dust ignition-proof drive motors, dusttight motor starters, and reduction gear units.
** The conveyors shall be as designed by Malone Conveying Company or acceptable equal. Steel troughs and screw devices shall be as manufactured by Fort Worth Steel and Machinery Company or acceptable equal. Screw Conveyor Corporation.

2I.2 DESIGN CONDITIONS. The coal silo unloading conveyors shall be designed in accordance with the following criteria.

Material handled	1-1/2" x 0" subbituminuous coal
Density	50 lb per cubic foot
Capacity	100 tons per hour
Ambient temperature, minimum	50 F
Ambient temperature, maximum	120 F
Material temperature, maximum	800 F smoldering coal
Location	Indoors

The screw conveyors shall be designed to convey 1-1/2" x 0" coal at an uncontrolled rate through a 16 inch OD pipe connection from overhead coal silos. The maximum height of coal in the silo is 90 feet above the inlet to the screw conveyors.

2I.3 CONSTRUCTION. The screw conveyors shall be constructed in accordance with the following requirements.

Each conveyor shall be provided with a screw feeder section of approximately 14 inch nominal size and shall present a 28'-0" dimension from the center line of the inlet flange to the center line of the outlet flange. The coal silo unloading conveyors shall be as indicated on Drawing S-7645-100678-1 included as a part of these specifications.

* Refer to page 5-3 of Contractor's Clarifications and Interpretations.
** Revised for Contract.

2I.4 DRIVE. Each conveyor shall be equipped with a mounted reduction gear and an electric motor of not less than 15 horsepower. The motor drive shall be complete with multiple V-belts and belt guards.

2I.5 SUPPORT. Each screw conveyor shall be furnished with conservatively rated struts, axles and wheels with solid rubber or phenolic treads. Swivel type caster wheels or acceptable equal arrangement shall be provided at the inlet end to provide ease of alignment and mobility on a flat traffic surface. A locking device shall be provided for the swivel.

2I.6 BEARINGS. Bearings shall be designed for a maximum of 800 F.

2I.7 CONNECTIONS. All trough inlet and discharge connections shall be flanged and equipped with mechanical joint, Dresser or other acceptable connectors to provide compensation for minor misalignment. Inlet and outlet termination points shall match up to 16 inch 125 pound lightweight flanges.

2I.8 TROUGH. The trough sections shall be suitably reinforced and furnished with top flange construction. Trough covers, screw clamps and gasketed surfaces shall be provided. The design shall provide a commercially dusttight enclosure.

2I.9 MATERIALS OF CONSTRUCTION.

Trough and plate steel	Mild steel A36 or manufacturer's standard. Minimum thickness: trough - 3/16 inch flanges - 1/4 inch
Screw conveyor shafts	C-1045 cold rolled steel, hardened 1/16 inch deep Rockwell Scale "C" 50-60
Screw conveyor flight	ASTM A514 steel
Center pipe	A-53 or manufacturer's standard
Hangers	Expansion Type 326 or acceptable equal with hard iron bearing inserts

2I.10 SHOP FABRICATION. The screw conveyors shall be completely shop fabricated and assembled. The support strut, wheel and axle assemblies may be removed to facilitate shipment. The completed assembly shall be test operated at the factory under no load conditions.

2I.11 PAINT. High temperature paint designed for 800 F shall be used.

ASTM A36 steel shall be prime painted with inorganic zinc-rich primer.

2I.12 ELECTRICAL REQUIREMENTS. This article covers electrical requirements for the coal silo unloading conveyors.

All equipment shall be designed for operation from a 480 volt, 3 phase, 60 hertz power supply.

All electrical equipment for each conveyor shall be permanently mounted on the respective conveyor unless specified otherwise.

All interconnecting cable and raceway shall be furnished and shall be in accordance with the requirements of Section 1B.

2I.12.1 Contractor-furnished Motor Starters. Each motor shall be furnished with a motor starter in accordance with the requirements of Section 1B.

2I.12.2 Motors. Motors shall be furnished in accordance with the requirements of Section 1D.

2I.12.3 Control. A conveyor control system with all protective interlocks shall be furnished and connected to a local control panel mounted on each conveyor. Each control panel shall contain the required control relays, switches, and indicating lights for local operator control. Control power shall be from the same source as the conveyor drive motor. Instrument and control devices shall be in accordance with the requirements of Section 1B.

2I.12.4 Cord and Plug Assemblies. Each conveyor shall be furnished with a 50 foot cord and plug assembly for connecting the conveyors to the permanent plant electrical system.

The cable shall be 3 conductor with ground, NEC Type SO, rated 600 volts, insulated with Type RH rubber, and jacketed with chlorosulfonated polyethylene, and shall be as manufactured by Boston Insulated Wire and Cable Company, Anaconda Wire and Cable Company, or acceptable equal.

The plug shall be 3 pole, 4 wire Pyle-National "BM" Series or acceptable equal.

2I.12.5 Receptacles. The Contractor shall furnish receptacles and enclosures to be installed in the permanent plant electrical system under separate specifications.

The receptacles shall be designed for use with the mating plug described previously and shall be 3 pole, 4 wire, Pyle-National "BM" Series or acceptable equal.

The bidder's Base Bid price shall include furnishing seven receptacles complete with enclosures, and the bidder's price for Unit 5 Option shall include furnishing seven additional receptacles complete with enclosures.

Docket No. 060658-EI
Silo Unloading
Exhibit No. _____ (JAB-14)
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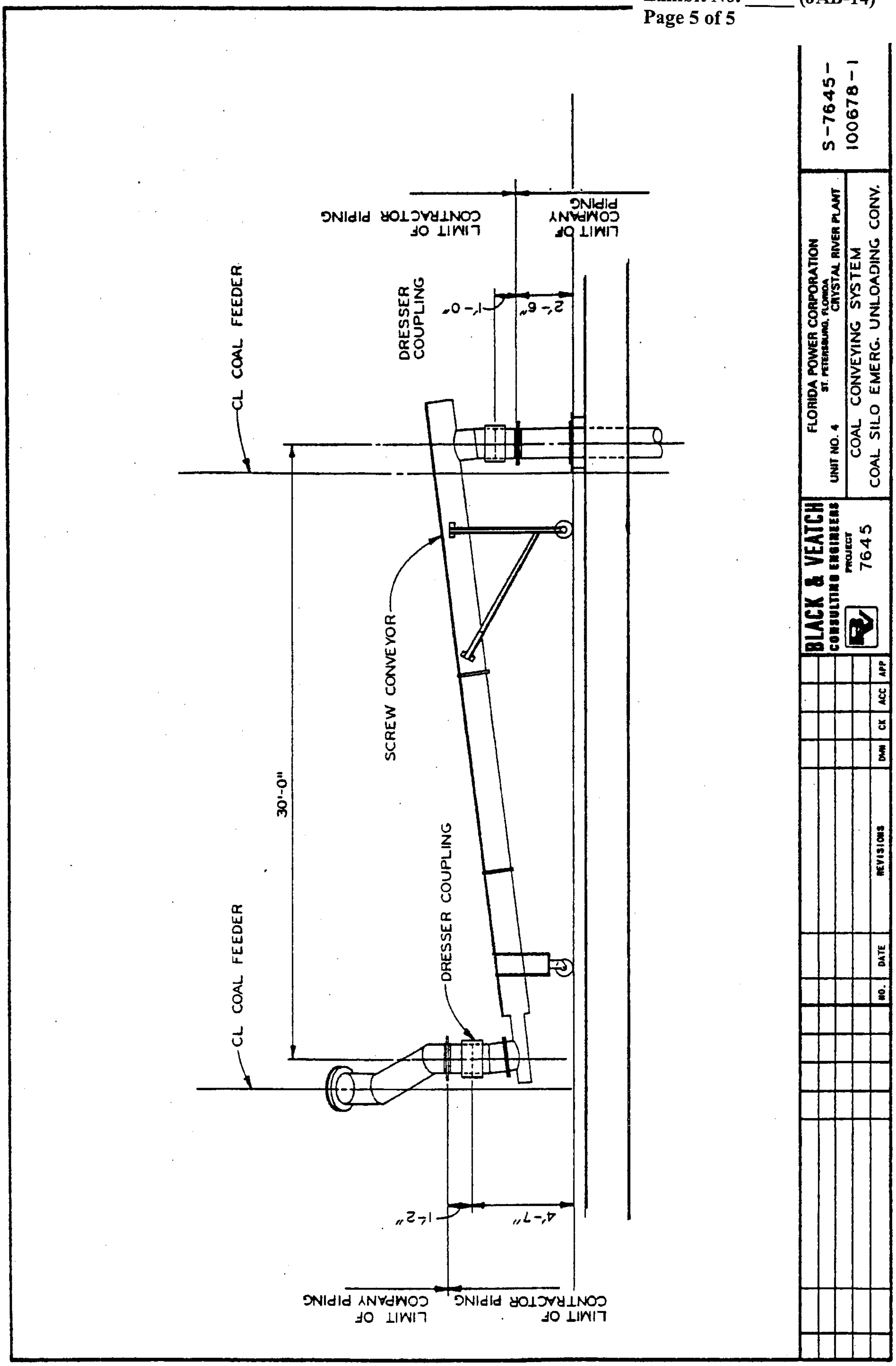


Observations From Initial PRB Test Burn
Crystal River Unit 4
April 26-28, 2004

Powder River Basin coal was initially tested in blend form in Crystal River Unit 4 to look at the feasibility of incorporation into the fuel mix. Not only is PRB one of the cheapest coals available based on the current market, but there are some potential benefits (such as NOx, SOx production) that are of interest at this time.

PRB test coal originated from Peabody's Antelope Mine near Gillette Wyoming. PRB is commonly available in two grades; 8400 or 8800 Btu products. The 8800 product was selected for testing. Coal was transported by Burlington Northern Railroad to Cahokia Terminal and transferred to river barge for transit to International Marine Terminal in New Orleans. Quality Data for bunkered samples, PRB, and the test barge are shown in appendix A.

PRB is commonly known for dustiness, and propensity for spontaneous combustion. In the boiler, it is generally known for it's long lazy flame which tends to focus the heat in the back end of the unit. It is also common to see extreme fouling and slagging effects on high percentage burns.

An initial test blend of 15% was established based on exceeding the typical unit derate specification of 11700 Btu. Blend coals used were Central Appalachian and Venezuelan compliance coals. The base ratio of 60/40 Central Appalachian to Venezuelan mirrors current tonnage commitments. This blend also capitalizes on the high Btu of the Venezuelan and the stable LOI production of the Central Appalachian. Overall, the initial target blend was 15% PRB, 50% Central Appalachian, and 35% Venezuelan. Quality data is shown in appendix B and C.

The three component blend was accomplished on the Amy Thompson April 23-24, 2004 at IMT. The base Central App and Venezuelan coals were loaded from ground storage using IMT's sophisticated scale based feeder system. The PRB component was added manually from river barge (i.e. not computer controlled). This method worked fairly well for holds 2,3, and 4. There was, however, an increase in percentage on the number 1 hold for the PRB percentage up to as much as 22%. This was likely the result of barge switching and reestablishing the blend feed ratios in manual mode. The coals were all extremely dry, receiving no rain in several weeks.

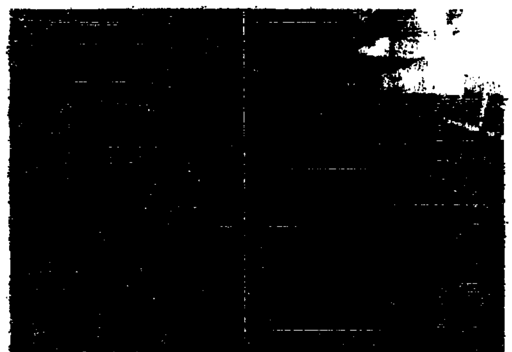
Temperature monitoring of the gulf barge loading was performed using an Ircon fixed mount infrared device. Temperatures at loading centered around 90 degrees with no hot spots indicated.

The Amy Thompson arrived at Crystal River and began to discharge directly to Unit 4 the night of April 25th. The coal began to show up in the furnace the morning of the 26th. The direct bunkering continued until approximately 8 am on April 28th. Coal from hold 1 showed up in the furnace on April 27th.

Coal Handling/Dust

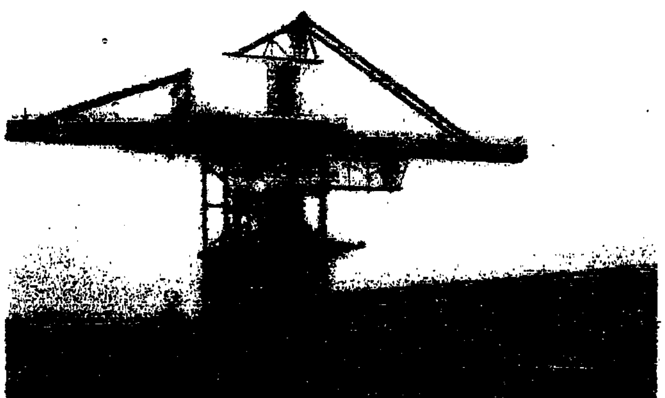
The PRB coal sizing was exhibited a coarser product than expected. Not only was this advantageous to the flow characteristics, but it also provides less surface area for the production of spontaneous heating effects as well as dust. A moderate amount of dust was seen as the dry 100% PRB was put to storage at IMT.

Good Sizing



Some Dust at IMT Discharge

No dust was observed at Crystal River on the blended cargo. No chute plugs or other handling issues were experienced.



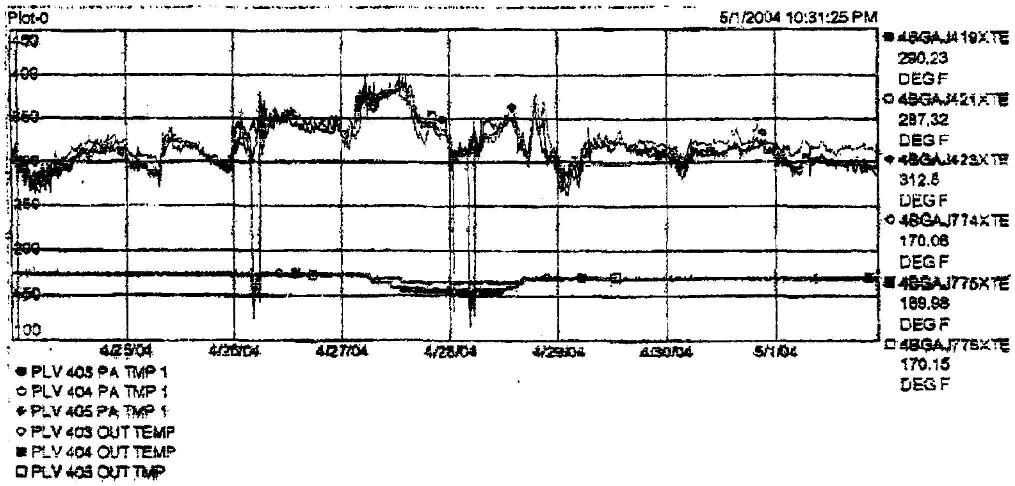
No Dust Unloading the blend at CR

Mill Performance

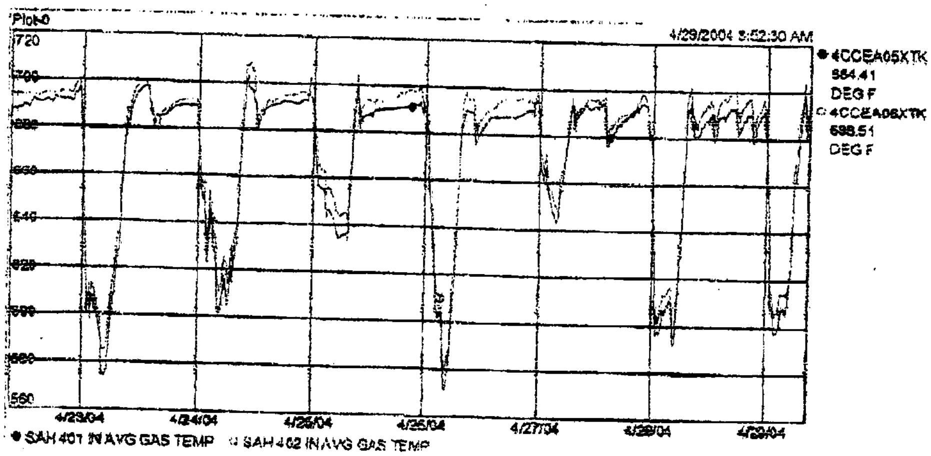
The 15% blend showed a slight increase in feeder speeds from approximately 63% to 65-67%. These are well within control ranges. Mill inlet temperatures rose from a nominal 300-degree level to around 350 degrees. Outlet temperatures were able to maintain at 175 degrees. Mill differential pressures were not noticeably changed.

For the 22% level blend, feeder speeds rose to the 69-70% range. Mill inlet temperatures rose to around 400 degrees. Operators lowered the mill outlet temperatures to 155-160 degree levels in order to bring down the inlet temperature. The Bailey control system locked at the feeder speeds and various other items and conducted a "Btu runback" dropping load from once from 760 MW to 745 MW and on a second occasion to 730MW. Once the 22% blend material passed the unit returned to the 15% settings. There was an increase in opacity during the passing of the 22% material up to the 15% opacity range.

Due to the softer grindability of the PRB coal (55), it is quite possible that full load could be achieved by manipulating the logic or running in manual. It is felt there is adequate mill capacity left.



Mill temperature Plots



Air Heater Inlet Temps

Similarly the air heater inlet temperatures show no significant change. This was the closest indicator to FEGT temperatures readily accessible to me.

Slagging and Fouling

Soot blower activity was not noticeably increased at any level. It is also assumed that at 15-20% PRB there simply was not enough accumulation of material to be noticed. In total only 2400 tons was in the blend at approximately 4% ash. Consequently, only 96 tons of PRB ash was present over the four days of burn.

Conclusions

While one barge load should not be considered as answering all the questions about this material, some things have become evident. First, from a load point of view, it was a fortunate accident that a hold of 22% was included in this test. It readily and fortunately, only briefly, indicated where we would notice the presence of the PRB. From the chart below, it is relatively easy to see the 22% area on the 27th.

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Benefits of PRB
Exhibit No. ____ (JAB-16)
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Benefits of PRB

- **Potential fuel cost savings**
- Enhanced fuel flexibility
- Demonstrate prudence
- Procurement and transportation leverage
- Environmental co-benefits:
  - lower sulfur content
  - lower NOx production
  - Lower ash & less abrasive

Progress Energy

Docket No. 060658-EI
Benefits of PRB
Exhibit No. _____ (JAB-16)
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Why CRN?

- **Units were designed for 50% PRB**
  - Large boiler box
  - Large ESP
  - Sprinkler systems, dust collectors, mill inerting exist; but repairs needed
  - Fuel handling can support with few mods

- **Competitive Advantage – location**
  - Gulf coast allows easy access from IMT
  - Can barge down Ohio River
  - Supplier diversity

Progress Energy

PRB Concerns & Mitigation Strategies

STOP

1	**Spontaneous Combustion Risk**	Keep < 30% PRB blend. Preblend product off-site. Replace dust collectors. Add foggers at TP's. Fuel handling training on PRB Best Practices.
2	**LOI increase**	PRB lowers NOx. Increase O2 and runback up to NOx limit. LOI decrease.
3	**Increased slagging/fouling potential**	Repair exist. sootblowers. Box and convective pass are adequately sized.

Progress Energy

SYSTEM DESIGN SPCIFICATION

	SYSTEM DESIGN SPECIFICATION	FILE NO. 7645.42.1207.12	
	COAL HANDLING CONTROL		REV 0

PROJECT: Florida Power Corporation NO.: 7645

CATEGORY: Coal Handling CODE: None

QUALITY LEVEL: Coal Handling Control CODE: CDF

REV	PREPARED BY	DATE	REVIEWED BY	DATE	APPROVED BY	DATE
A	A. L. Carlson a.L.C.	8/28/79	R. L. Hollrah RLH	8/28/79		
	P. L. Grandcolas PLG	8/28/79				
B	A. L. Carlson a.L.C.	8/28/79	R. L. Hollrah RLH	8/28/79		
	P. L. Grandcolas PLG	8/28/79				
0	A. L. Carlson a.L.C	4/1/80	R. L. Hollrah RLH	4/1/80	R. G. Ruisch RGR	4/2/80
	P. L. Grandcolas PLG	4/1/80				

REV	LIST OF REVISED PAGES

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	SYSTEM DESIGN SPECIFICATION	FILE NO. 7645.42.1207.12	
	COAL HANDLING CONTROL		REV 0

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SYSTEM DESIGN SPECIFICATION FOR COAL HANDLING CONTROL

FLORIDA POWER CORPORATION
CRYSTAL RIVER PLANT
UNIT 4
PROJECT 7645

1.0 SYSTEM DESCRIPTION

1.1 SYSTEM IDENTIFICATION

(1)	Category Name	Coal Handling
(2)	Category Code	None
(3)	System Name	Coal Handling Control
(4)	System Code	CDF
(5)	B&V File No.	7645.42.1207

1.2 FUNCTION

The Coal Handling Control System will consist of the North Coal Yard Control System, the South Coal Yard Control System, and the Rail Car Unloading Control System. The function of the North Coal Yard Control System will be to provide control of the coal stockout, reclaim, and coal crushing and silo fill systems to achieve coal requirements for Units 4 and 5. This system will provide all necessary control from Transfer Point 25 through and including Units 4 and 5 coal silos.

The function of the South Coal Yard Control System will be to provide control of the barge coal stockout, south coal yard coal reclaim and stockout bypass, and mobile reclaim to achieve coal requirements for Units 1 and 2 and Units 4 and 5. This system will provide all necessary control from the discharge of the barge hopper feeder to Units 1 and 2 plant transfer hopper or to Transfer Point 25.

The function of the Rail Car Unloading Control System will be to provide control of rail coal stockout either to Units 1 and 2 or to Units 4 and 5. This system will provide all necessary control from the discharge of the rail car unloader feeders to the radial stacker or to Transfer Point 25.

1.3 PROCESS DESCRIPTION

The Coal Handling Control System will control and monitor operation of all of the equipment within the Coal Handling System. This includes conveyors, diverter and splitter gates, sample systems, dust collectors, coal feeders, and stacker/reclaimers. Coal flow rate analog and digital logic will be developed in the programmable controller. Coal flow rates will be adjustable from the coal handling control panel.

1.4 INTERFACING SYSTEMS

The significant systems which interface with the Coal Handling Control System are listed on Table 1-1.

TABLE 1-1. INTERFACING SYSTEMS

System	System Code	Interface		
		Physical[a]	Functional[b]	Supportive[c]
Auxiliary Power Supply System	APX		X	
Coal Handling Structures	BSH			X
Coal Sampling	CHA		X	
Coal Crushing and Silo Fill	CHE		X	
Coal Weighing	CHG		X	
Coal Handling Dust Control	CHI		X	
Grounding	EEB	X		
Raceway	EEC			X
Equipment Fire Protection	FPA		X	

[a]A physical interface denotes a physical connection between interfacing systems; e.g., the interface between the grounding system and the Coal Handling Control System.

[b]A functional interface denotes an interface between systems where there is no physical boundary; e.g., the CHA system.

[c]A supportive interface denotes an interface between a system and a support structure; e.g., the interface between the Coal Handling Control System and the coal handling structures.

2.0 SYSTEM DESIGN CRITERIA

2.1 SUPPORTIVE DOCUMENTATION

The supportive documentation for the system design criteria is as follows.

(1) System Design Specification--Coal Stockout and Reclaim.

(2) Coal Conveying Equipment--Specification File No. 7645.61.4220.

2.2 CODES AND STANDARDS

Codes and standards applicable to the Coal Handling Control System are listed under the Codes and Standards section of the Component Design Criteria.

2.3 REGULATORY REQUIREMENTS

Not applicable.

2.4 QUALITY CLASSIFICATION

See the Project Design Manual.

2.5 NATURAL PHENOMENA

Natural phenomena for the project are listed in the Project Design Manual, Section 3.3.

2.6 INTERFACING SYSTEMS

The interface description and applicable criteria for systems listed in Table 1-1 are specified below. Only systems which impose constraints on the Coal Handling Control Systems or systems on which the Coal Handling Control Systems imposes constraints are listed.

2.6.1 Auxiliary Power Supply System (APX)

Three divisions of the Auxiliary Power Supply System interface functionally with the Coal Handling Control System. These portions are the APB, APC, and APG which are described as follows.

The AC Power Supply (120 V control) System (APB) provides 120 V AC power for the programmable controller, multiplexes, I/O cabinets, and field mounted equipment. Power will be furnished through several buses located throughout the coal yard.

The Auxiliary Power Supply System for the coal yard (480 V-APC and 4,160 V-APG) will be controlled and monitored by the Coal Handling Control System. The interface between these systems will occur on the mimic panels located on the north and south coal handling control panels.

2.6.2 Coal Handling Structure (BSH)

The north coal handling control panel is supported by the floor of the control room of the Coal Crusher Building No. 2. The south coal handling control panel is supported by the floor of the south coal yard control room located near the Units 1 and 2 crusher house.

2.6.3 Coal Sampling (CHA)

The Coal Sampling System will be interfaced with the Coal Handling Control System by means of a selector switch on the coal handling control panel with functions for automatic or local control. Inputs for status and alarms will be monitored by the Coal Handling Control System.

2.6.4 Coal Crushing and Silo Fill (CHE)

The interface between the Coal Crushing and Silo Fill and the Coal Handling Control System will be the control and alarm circuits of the various components of the Coal Crushing and Silo Fill Systems. Contact sensing circuits will be provided for input of equipment status. Analog signals will be used to provide control of the Silo Fill System feed rate.

2.6.5 Coal Stockout and Reclaim (CHB)

The interface between the Coal Stockout and Reclaim and the Coal Handling Control System will be the control and alarm circuits of the various components of the Coal Stockout and Reclaim System. Contact sensing circuits will be provided for input of equipment status to the control system. Analog signals will be used to provide control of the stockout and reclaim feed rates.

2.6.6 Coal Weighing (CHG)

Analog signals from conveyor belt scales will be provided as the functional interface between the Coal Weighing and Coal Handling Control Systems. Signals will be provided from belt scales on Conveyor 2, 4, 11, 31, 32, 34, 35-A, 35-B, 401, 404, 501, and 503.

2.6.7 Coal Handling Dust Control (CHI)

The Coal Handling Dust Control System will be interfaced by control circuits from the Coal Handling Control System. As various components of the Coal Handling System are started, the associated dust control equipment

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will also be started by interlocked control circuits. Local control operation will be also available to the operator at the dust collector locations.

2.6.8 Grounding (EEB)

The Grounding System provides an independent electrical connection for the logic elements of the Coal Handling Control System. Individual ground rods are required to ground the control system cabinets to protect personnel and electronic circuitry from high voltage transients.

2.6.9 Raceway (EEC)

The Raceway System provides mechanical support and protection for cables and wiring throughout the coal yard area and between the Coal Handling Control System and other systems.

2.6.10 Equipment Fire Protection (FPA)

The Equipment Fire Protection System provides input to the Coal Handling Control System, which upon actuation will cause the tripping of affected equipment in the Coal Conveying System. The fire protection inputs will be located throughout the coal yard and will input into the Coal Handling Control System.

2.7 OPERATING CONDITIONS

2.7.1 Normal Operating Conditions

The ambient temperature range must not fall outside the range 15 to 130 F. Relative humidity limitations, if any, will be as provided by the equipment manufacturer.

2.8 REDUNDANCY

The Coal Handling Control System for the north and south coal yards will each have a remote programmable control system and a local hardwired limited interlock control system.

2.9 FUNCTIONAL CONSTRAINTS

The Coal Handling Control System will consist of a separate control system for the north coal yard, south coal yard and rail car unloader. The North Coal Yard Control System will function to accomodate Units 4 and 5. The South Coal Yard and Rail Car Unloader Control Systems will function to accomodate both Units 1 and 2, and 4 and 5.

2.10 PHYSICAL CONSTRAINTS

Not applicable.

2.11 PROCESS CONTROL

Three control systems will be provided in two control panels: North Coal Yard Control System in the north coal yard control panel, South Coal Yard Control System and Rail Car Unloading Control System in the south coal yard control panel.

2.11.1 North Coal Yard Coal Handling Control System

Three modes of control will be provided, as follows.

(1) Program Mode--Operator sequential start-up guidance at the north coal handling control panel with equipment interlocking and monitoring, and trouble and information alarms.

(2) Manual Mode--Operator start-up of equipment out of sequence at the north coal handling control panel.

(3) Local Mode--Local equipment start-up.

2.11.1.1 Program Mode. In this mode of operation, the operator will be guided by the programmable controller through the start-up sequence of all equipment required for the desired movement of coal. The start-up selections will be presented to the operator in the correct sequence by flashing each backlighted pushbutton in sequential order required for start-up in the selected submode.

The program mode has four submodes: Stockout, Reclaim, Reclaim and Stockout Bypass, and Stockout Bypass. They are described as follows.

(a) The selection of the "Stockout" submode will require the operation of all equipment for Transfer Point 25 to the active storage piles of the selected stacker/reclaimer(s). The stacker/reclaimer(s) can be operated individually or simultaneously with the stockout coal divided between them. Coal flow rate(s) will be selected by the operator at the north coal handling control panel. The Coal Crushing and Silo Fill Systems will not operate in this submode.

(b) Selection of the "Reclaim" submode will require the operation of all equipment from the stacker/reclaimer through the silos of the selected unit(s). Operation of equipment to convey coal from the south coal yard to the stacker/reclaimer will not operate in this submode. The operator will have a choice of operation of one or both stacker/reclaimers.

(c) The "Reclaim and Stockout Bypass" submode will require the operation of all equipment from Transfer Point 25 through both stacker/reclaimers, and all equipment to the silos of the selected unit(s). This submode will allow coal flow from the south coal yard to be split at Transfer Point 26 with part of the flow being stocked out through Stacker/Reclaimer 2 and the rest bypassed to be mixed with coal being reclaimed by Stacker/Reclaimer 3. The reclaim and the bypass rates will be selected by the operator at the north coal handling control panel. The coal will then proceed on to be crushed and distributed to the silos.

(d) The "Stockout Bypass" submode selection will require the operation of all equipment from Transfer Point 25 through the selected stacker/reclaimer and to the silos of the selected unit(s). This submode will allow coal from the south coal yard to be divided between stockout and silo filling at a rate selected by the operator at the north coal handling control panel.

Once the program mode has been selected, the operator must select one of the four submodes described above. After this selection is made, the equipment selection required for operation will be indicated by the backlighted pushbuttons and indicating lights on the control panel. The programmable controller logic programs will limit equipment start-up to the submode selected and will limit the operator's switch selection to assure a sequential start-up. Once the respective equipment has been started, the indication will show a running state has been achieved. Start-up of alternate pieces of equipment can be accomplished while in the program mode. If alternate path selections are available, the coal flow path can be changed and the original running equipment can then be stopped.

2.11.1.2 Manual Mode. In this mode, the operator will have full responsibility for manually starting and stopping individual pieces of equipment

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in the system from the north coal handling control panel. Interlocking, monitoring, and alarming will be provided by the controller. Sequential tripping will be established only when two pieces of equipment are operating in sequence.

2.11.1.3 <u>Local Control</u>. Local control will be provided for local testing or local control of individual pieces of equipment. All remote starting control shall be isolated from the programmable controller by local control switches located near the equipment drive motors.

Inputs received during operation in local control will be provided to the programmable controller as status information only.

The coal sample systems, the stacker/reclaimers, and the dust collection system will have local control which will allow them to independantly be taken out of programmable controller control and be controlled locally.

2.11.1.4 <u>Silo Fill Control</u>. The North Coal Handling Control System will monitor the level of the silos in the plant and will supervise and control the Coal Handling System from start-up through shutdown, including coal flow rate control as outlined herein. Coal silo level control and indication will be provided by use of load cells mounted under each silo. The Coal Handling System can deliver coal over several different "Paths"; to Unit 4, to Unit 5, or both. Path selection will be made by the operator at the coal handling control panel.

When the appropriate equipment has been started, the controller will monitor and control the silo filling operation. As the last selected silo is approaching the filled condition, the controller will direct the coal flow to assure all conveyors will purge. There are two separate examples.

(1) When coal is being received from the existing coal yard for the silo filling operation and the last coal silo approaches the full condition, the control system will divert all coal to the stacker/reclaimer in operation for stockout. The crusher hopper and plant surge hopper feeders will operate until the last silo reaches the "silo cascade conveyor purge limit". At this point, the feeders will stop but the silo cascade conveyors will continue to run, allowing them to purge. Crusher Hopper 2 and the Plant

Surge Hopper 2, operating at minimum level, will accommodate the remaining coal on their preceding conveyors, allowing them to purge.

(2) When coal is being received from the stacker/reclaimer(s) and the coal silos are approaching the full condition, the control system will stop the stacker/reclaimer(s) first, followed by the same purge sequence as outlined in Example 1.

2.11.1.5 Rate Selection. Rate selection will be made at the north coal handling control panel to regulate the amount of coal to: (1) Conveyor 33 from Transfer Point 26 and (2) Conveyor 35-A and/or 35-B from Transfer Point 27.

In the reclaim and stockout bypass submode the rate signal for Transfer Point 26 will regulate Splitter Gate 26, splitting coal between Conveyors 32 and 33. The rate signal for Transfer Point 27 will regulate the Stacker/ Reclaimer 3 reclaim rate. In this submode coal will be blended at Transfer Point 27.

In the stockout submode the rate signal for Transfer Point 26 will regulate Splitter Gate 26 only when both stacker/reclaimers have been selected for stockout and Conveyor 33 is running. The rate signal for Transfer Point 27 would not be active in this mode.

In the reclaim submode the rate signals for Transfer Points 26 and 27 would regulate Stacker/Reclaimers 2 and 3 reclaim rate.

In all submodes, the maximum rate (total of both rate selections) will be automatically adjusted to conform to the downstream capacity capabilities. This will take into account the number of conveyors running downstream of Transfer Point 27 and the number of plant transfer hopper feeders in operation.

The flow rate past Transfer Point 27 will be equally split between Conveyors 35-A and 35-B when both are operational. Flow rate on each conveyor will be automatically adjusted by the actual measured flow rate.

2.11.1.6 Purge Conditions. Purge conditions will be established either automatically or manually from the coal handling control panel. In both cases the incoming coal will either be diverted or stopped allowing the conveyors to purge. A program submode "Stop Purge Complete" selection will be provided and will only be available for operator selection when the purge sequence is complete.

2.11.1.7 Emergency Stop. A guarded emergency stop pushbutton will be provided on the north coal handling control panel for situations requiring immediate action. This pushbutton will be active in both the manual or program mode and will stop all equipment from Transfer Point 25 to the silo cascade conveyors. A hardwired stop interlock will also be available to the south coal yard which will stop equipment in that area.

2.11.2 South Coal Yard Coal Handling Control Systems

A programmable controller (PC) will provide control from the south coal handling control panel of both the South Coal Yard Coal Handling Control System and the Rail Coal Unloading Control System. The control systems will have two modes of control: (1) remote and (2) local.

In the remote mode the operator will be guided (by the program in the programmable controller) in the sequential start-up of the paths for the South Coal Yard Coal Handling Control Systems. The start-up selections will be presented to the operator in the correct sequence by flashing each button in sequential order required for start-up in the selected path.

The local control mode of operation will provide for local testing or local control of individual pieces of equipment. Remote starting and stopping sequences shall be isolated from the programmable controller by local selector switches. Status inputs will be supplied from the selector switches to the programmable controller for logic and status information.

2.11.2.1 South Coal Yard Coal Handling Control System Paths. Barge coal destinations will be directed by the operator from the south coal yard coal handling control panel located in the south coal yard control room near the Units 1 and 2 crusher house. The system may be operated in either the remote mode or in local control.

The remote mode has five paths: Stockout, Stockout Bypass, S/R Reclaim, North Yard Barge Coal, and Mobile Reclaim. They are described as follows.

(1) The selection of the Stockout path will require the operation of the Stacker/Reclaimer, Conveyor 3A, Conveyor 2 and Conveyor 1.

Transfer to the Stockout bypass operation will be possible from this path.

(2) Selection of the Stockout Bypass path will require the operation of Conveyor 5, one or both crushers, the Stacker/Reclaimer, Conveyor 4, Conveyor 3A, Conveyor 2, and Conveyor 1. The bypass rate will be selected by the operator at the south coal handling control panel. Blending may be accomplished by start-up of Conveyor 9 and start-up and adjustment of the mobile reclaim feeder from the south coal handling control panel.

(3) Selection of the S/R Reclaim path will require the operation of Conveyor 5, one or both crushers, the Stacker/Reclaimer, Conveyor 4, and Conveyor 3A. Rate control will be selected by the operator for the south coal handling control panel. Stacker/Reclaimer reclaim control is done by local manual operation.

(4) The selection of the Mobile Reclaim path will require the operation of Conveyor 5, one or both crushers, Conveyor 4, Conveyor 9, and the mobile reclaim feeder. The feeder rate shall be selected by the operator from the south coal handling control panel.

(5) Selection of the North Yard Barge Coal path will require the operation of Conveyor 30, Conveyor 29, Conveyor 3B, Conveyor 2, and Conveyor 1.

2.11.2.2 Rail Coal Unloading Control System. The rail coal paths shall be controlled from the existing control room near the rail car unloading hoppers. The operator will be able to operate the coal handling equipment in the rail coal paths from a subpanel to be installed on the existing control panel.

The remote mode for this system has two paths: South Yard Rail Coal and North Yard Rail Coal. They are described as follows.

(1) The selection of the South Yard Rail Coal will require the operation of the radial stacker, Conveyor 14, Conveyor 12, Conveyor 11, Conveyor 10, and the rail coal hoppers feeders.

(2) The selection of the North Yard Rail Coal will require the operation of Conveyors 30, 13, 11, and 10, and the rail coal hopper feeders.

2.11.2.3 Emergency Stop. Guarded emergency stop pushbuttons will be provided on the south coal handling control panel and on the rail coal control subpanel for situations requiring immediate action. This pushbutton will be active in all paths of remote operation.

2.12 SYSTEM TESTING

The system will be tested as outlined in Section 3.9.

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3.0 COMPONENT DESIGN CRITERIA.
NORTH COAL HANDLING PROGRAMMABLE CONTROLLER

3.1 FUNCTION

The North Coal Handling Programmable Controller (NCHPC) will provide logic functions for the Unit 4 and 5 Coal Handling System. These logic functions will provide discrete or concurrent operation of the coal stock-out, coal reclaim, and silo filling and will provide interlocking and monitoring of equipment in both the manual and program modes.

3.2 DESCRIPTION

A block diagram (see Figure 3-1) has been included which outlines the position of the NCHPC in the control system.

The NCHPC will consist of a solid state central processing unit, memory, timers, counters, and input/output points. The NCHPC will be programmed to provide control logic which performs analog and digital control, alarm, and information functions.

The NCHPC may be reprogrammed to change the control logic arrangement through a limited access logic programmer panel.

3.3 BOUNDARIES

The boundaries of the NCHPC exist as shown in Figure 3-1.

3.4 CODES AND STANDARDS

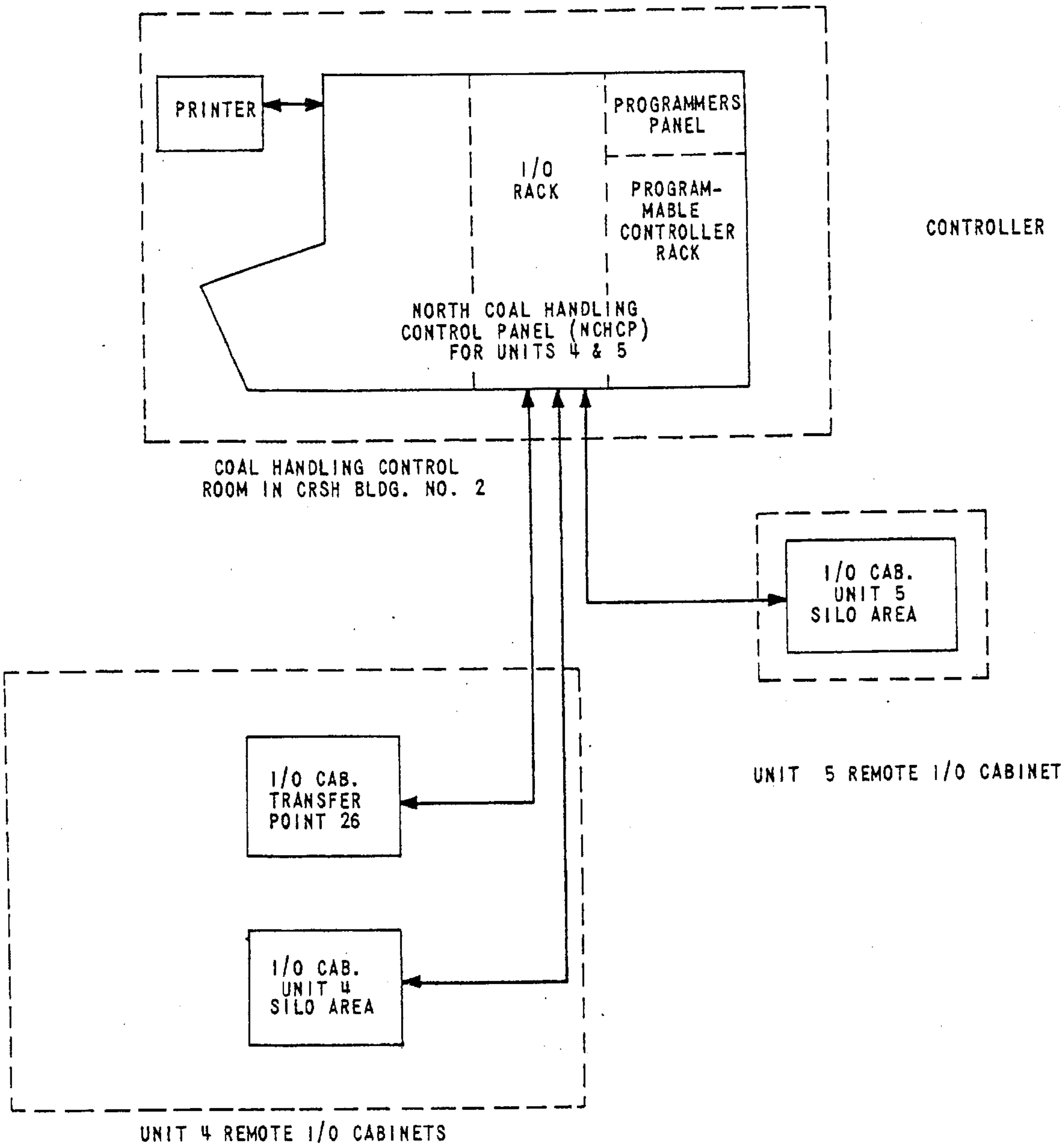
Except where specifically stated otherwise, all equipment furnished will conform to the latest applicable standards of NEMA, ASME, ISA, ANSI, IEEE, AND EEI as to rating, test, construction, and operation; and shall be in accordance with applicable requirements of the Federal Occupational Safety and Health Standards.

3.5 DESIGN CONDITIONS

The programmable contoller will be capable of accepting 120 volt AC or 125 volt DC inputs, supplying 120 volt AC or 125 volt DC commands, and accepting and supplying analog control signals.

Outputs will be buffered when necessary with external relays to provide sufficient control current.

Outputs used for information and for defining alarm locations will be provided in an English language format to the coal handling line printer.



UNITS 4 AND 5
COAL HANDLING CONTROL
SYSTEM CONFIGUTATION

FIGURE 3-1

3.6 FUNCTIONAL CONSTRAINTS

The programmable controller for Unit 4 and 5 will be mounted in the north coal handling control panel in the Coal Crusher Building 2 control room.

Input/output racks will contain all necessary interfacing equipment including terminal blocks, relays, and multiplexing equipment.

3.7 PHYSICAL CONSTRAINTS

None.

3.8 MATERIAL SELECTIONS

Not applicable.

3.9 TESTING

System checking shall consist of both factory and field tests. A complete test in the factory will be performed on the total system hardware and software. The programmable controller shall undergo a minimum of 100 hours burn-in prior to shipment. Additionally, the system will be completely tested in the field.

Solid state logic systems will be tested as complete assemblies. Testing of individual components or modules will not be acceptable.

3.10 ASSEMBLY AND SHIPPING

None.

3.11 SPARE PARTS

As per the manufacturer's recommendations.

P-GN-180B

4.0 COMPONENT DESIGN CRITERIA
SOUTH COAL HANDLING PROGRAMMABLE CONTROLLER

4.1 FUNCTION

The South Coal Handling Programmable Controller (SCHPC) will provide logic functions for the South Coal Yard Coal Handling System. These logic functions will provide discrete or concurrent operation of the coal stock-out, coal reclaim, and silo filling and will provide interlocking and monitoring of equipment in both the remote and local modes.

4.2 DESCRIPTION

A block diagram (see Figure 4-1) has been included which outlines the position of the SCHPC in the control system.

The SCHPC will consist of a solid state central processing unit, memory, timers, counters, and input/output points. The SCHPC will be programmed to provide control logic which performs digital control, alarm, and information functions.

The SCHPC may be reprogrammed to change the control logic arrangement through a limited access logic programmer panel.

4.3 BOUNDARIES

The boundaries of the SCHPC exist as shown in Figure 4-1.

4.4 CODES AND STANDARDS

Except where specifically stated otherwise, all equipment furnished will conform to the latest applicable standards of NEMA, ASME, ISA, ANSI, IEEE, AND EEI as to rating, test, construction, and operation; and shall be in accordance with applicable requirements of the Federal Occupational Safety and Health Standards.

4.5 DESIGN CONDITIONS

The programmable contoller will be capable of accepting 120 volt AC or 125 volt DC inputs and supplying 120 volt AC or 125 volt DC commands.

Outputs will be buffered when necessary with external relays to provide sufficient control current.

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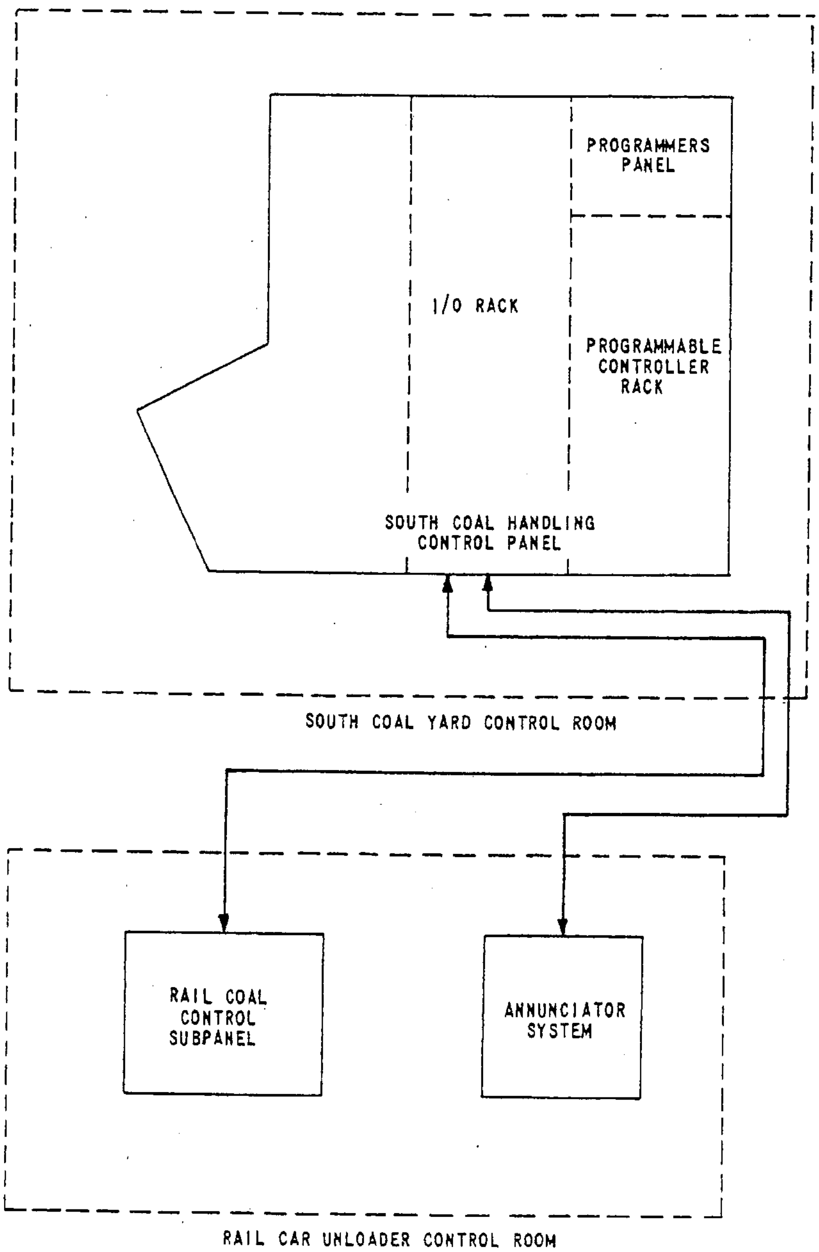

SOUTH YARD
COAL HANDLING CONTROL
SYSTEM CONFIGURATION

FIGURE 4-1

	SYSTEM DESIGN SPECIFICATION	FILE NO. 7645.42.1207.12	
	COAL HANDLING CONTROL		REV 0

4.6 FUNCTIONAL CONSTRAINTS

The programmable controller for the combined South Coal Yard and Rail Coal Unloading Control Systems will be mounted in the south coal handling control panel in the south coal yard control room.

Input/output racks will contain all necessary interfacing equipment including terminal blocks, relays, and multiplexing equipment.

4.7 PHYSICAL CONSTRAINTS

None.

4.8 MATERIAL SELECTIONS

Not applicable.

4.9 TESTING

System checking shall consist of both factory and field tests. A complete test in the factory will be performed on the total system hardware and software. The programmable controller shall undergo a minimum of 100 hours burn-in prior to shipment. Additionally, the system will be completely tested in the field.

Solid state logic systems will be tested as complete assemblies. Testing of individual components or modules will not be acceptable.

4.10 ASSEMBLY AND SHIPPING

None.

4.11 SPARE PARTS

As per the manufacturer's recommendations.

P-GN-180B

5.0 COMPONENT DESIGN CRITERIA REMOTE I/O CABINETS

5.1 FUNCTION

The I/O cabinets will provide an interface between the control system and the process. Inputs from field instrumentation and outputs from the programmable controller will be terminated in the I/O cabinets.

5.2 DESCRIPTION

The I/O cabinets will be located throughout the North Coal Yard Coal Handling System at discrete transfer points. Three of these locations are currently planned.

Multiplexing units in each I/O cabinet will be used to transmit signals between the programmable controller and the field mounted equipment. The multiplexers will convert process I/O signals to high frequency pulses and will transmit this information to and from the programmable controller's central processing unit.

5.3 BOUNDARIES

Boundaries of the I/O cabinets are as shown on Figure 3-1.

5.4 CODES AND STANDARDS

See Section 3.4.

5.5 DESIGN CONDITIONS

The I/O cabinets will be capable of accepting analog inputs and inputs in the form of electrically isolated contact closures, or equivalent solid state gates. The cabinets will contain the required interrogation power supplies for input status.

System outputs will be provided in the form of analog outputs and electrically isolated contact closures or equivalent solid state gates. The control system will be capable of switching the specified output loads. Protective devices required by the control system to protect the system from damage will be included in the system.

5.6 FUNCTIONAL CONSTRAINTS

I/O racks will be mounted inside cabinets with buffering relays (if necessary) and terminal blocks.

5.7 PHYSICAL CONSTRAINTS

None.

5.8 MATERIAL SELECTION

None.

5.9 TESTING

Refer to testing in Section 3.9.

5.10 ASSEMBLY AND SHIPPING

None.

5.11 SPARE PARTS

As per the manufacturer's recommendations.

6.0 COMPONENT DESIGN CRITERIA
NORTH COAL YARD OPERATOR INTERFACE EQUIPMENT

6.1 FUNCTIONS

The North Coal Handling Control Panel (NCHCP) will provide a means whereby the operator can command and monitor the various functions being performed by the system. The panel will also provide information as to the status of the various items of process equipment being controlled by the system.

6.2 DESCRIPTION

The NCHCP will be a double break, free standing panel. It will provide control information to the operator by means of indicating lights, graphic display sub-panel, electrical one-line mimic sub-panel, annunciators, and analog indicators.

Devices which will implement the operator's control of coal flow and system operation include coal feed rate adjusting controls, selector switches, and backlighted pushbutton switches.

A single pushbutton switch will be used to start and stop individual pieces of equipment. The alternate action to accomplish this will be done in the programmable controller's logic routine.

The pushbutton control sequence will be as follows.

(1) Equipment available to start--PB green lights on.

(2) Operator guided by PC to equipment pushbutton for start-up--pushbutton green lights flashing.

(3) Equipment selected, warning horn sounding--PB blank; no lights on.

(4) Equipment running--PB red lights on.

(5) Equipment tripped--PB flashing red lights on.

6.3 BOUNDARIES

The boundaries of the above described equipment can be seen by referring to Figure 3-1.

6.4 CODES AND STANDARDS

See Section 3.4.

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6.5 DESIGN CONDITIONS

The operator interfacing equipment will be installed in a space which is normally heated or cooled for personnel comfort. It is designed, however, for continuous operation under conditions imposed by an air conditioning failure for which ambient temperature may range from 50 to 130 F.

6.6 FUNCTIONAL CONSTRAINTS

Indicators and pushbuttons will be backlighted. Selector switches and pushbuttons will be grouped in functional arrangements.

6.7 PHYSICAL CONSTRAINTS

None.

6.8 MATERIAL SELECTION

Not applicable.

6.9 TESTING

See Section 3.9.

6.10 ASSEMBLY AND SHIPPING

None.

6.11 SPARE PARTS

As per the manufacturer's recommendations.

P-GN-180B

7.0 COMPONENT DESIGN CRITERIA
SOUTH COAL YARD OPERATOR INTERFACE EQUIPMENT

7.1 FUNCTIONS

The South Coal Handling Control Panel (SCHCP) will provide a means whereby the operator can command and monitor the various functions being performed by the system. The panel will also provide information as to the status of the various items of process equipment being controlled by the system.

7.2 DESCRIPTION

The SCHCP will be a double break, free standing panel. It will provide control information to the operator by means of indicating lights, graphic display panel, electrical one-line mimic panel, annunciators, and analog indicators.

Devices which will implement the operator's control of coal flow and system operation include coal feed rate adjusting controls, selector switches, and backlighted pushbutton switches.

A single pushbutton switch will be used to start and stop individual pieces of equipment. The alternate action to accomplish this will be done in the programmable controller's logic routine.

The pushbutton control sequence will be as follows.

(1) Equipment available to start--PB green lights on.

(2) Operator guided by PC to equipment pushbutton for start-up--pushbutton green lights flashing.

(3) Equipment selected, warning horn sounding--PB blank; no lights on.

(4) Equipment running--PB red lights on.

(5) Equipment tripped--PB flashing red lights on.

7.3 BOUNDARIES

The boundaries of the above described equipment can be seen by referring to Figure 4-1.

7.4 CODES AND STANDARDS

See Section 3.4.

SYSTEM DESIGN SPECIFICATION	FILE NO. 7645.42.1207.12	
COAL HANDLING CONTROL		REV 0

7.5 DESIGN CONDITIONS

The operator interfacing equipment will be installed in a space which is normally heated or cooled for personnel comfort. It is designed, however, for continuous operation under conditions imposed by an air conditioning failure for which ambient temperature may range from 50 to 130 F.

7.6 FUNCTIONAL CONSTRAINTS

Indicators and pushbuttons will be backlighted. Selector switches and pushbuttons will be grouped in functional arrangements.

7.7 PHYSICAL CONSTRAINTS

None.

7.8 MATERIAL SELECTION

Not applicable.

7.9 TESTING

See Section 3.9.

7.10 ASSEMBLY AND SHIPPING

None.

7.11 SPARE PARTS

As per the manufacturer's recommendations.

FLORIDA POWER CORPORATION
SYSTEM ANALYSIS
PROJECT FILE 7645.41.0601.22

COAL HANDLING

BLACK & VEATCH/consulting engineers

7/15/80

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PROJECT NAME: Florida Power Corporation, Crystal River 4

PROJECT NO.: 7645

REV	PREPARED BY	DATE	REVIEWED BY	DATE	APPROVED BY	DATE
A	G.L. Watts	2-6-78	R.L. Hollrah	2/6/78		
	E.K. Leclair		G.L. Christensen	2/6/78		
0	T. N. Birkett	TNB 6-5-80	J. W. Fitzwater	7/7/80	R. L. Hollrah	7/15/80
	D. T. Roush	7-1-80	G. L. Christensen	7/15/80	R. G. Ruisch	7/15/80

REV	LIST OF REVISED PAGES

N-179A

FLORIDA POWER CORPORATION
COAL HANDLING

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FOREWORD

Based upon the information presented in this analysis and other considerations developed in discussions between Florida Power Corporation and Black & Veatch, the conclusions stated in this analysis have been adopted for the design of the Crystal River Plant with the following clarification.

(1) Coal supply will be from Units 1 and 2 coal handling system; therefore, emergency stockout facilities inside the railroad loop are not required.

FLORIDA POWER CORPORATION
SYSTEM ANALYSIS
PROJECT FILE 7645.41.0601.22

COAL HANDLING

1.0 INTRODUCTION

The Florida Power Corporation has proposed to construct two 670 MW coal-fired units at the existing Crystal River Station. The objective of this analysis is to determine the optimum coal handling system for these units and to describe the basic design parameters, operational procedures, and major components thereof.

2.0 SUMMARY

2.1 SUMMARY OF IMPORTANT INFORMATION

(1) The Units 4 and 5 stockout and reclaim system will receive coal from the existing barge unloading and railcar unloading facilities. The new system will interface with the existing system for Units 1 and 2.

(2) The stockout and reclaim system will provide for the handling, storage, and blending of at least two types of coal. Complete segregation of the two coals is required.

(3) Approximately 855,000 tons of reserve storage will be provided for 90 days fuel requirements for both units operating at 60 per cent capacity.

(4) The stockout and reclaim system will provide 43,000 tons of active storage for 3 days fuel requirements for both units operating at 90 per cent capacity.

(5) The maximum design burn rate for Units 4 and 5 is 330 tons per hour per unit or 660 tons per hour total, based on a design coal heating value of 10,285 Btu per pound.

(6) The coal silo storage for Units 4 and 5 will provide for 8 hours operation for each unit based on the maximum design burn rate.

(7) The general arrangement of the coal handling system will be as follows; from the barge and rail unloading points at Units 1 and 2 a conveyor system will be added to and modified to converge with a single 2,500 tph belt conveyor system which will convey the coal to the north coal yard, where the active and reserve storage piles will be located.

Dual 800 tph conveyors will transport the coal from the north coal yard to the Coal Crusher Building which will have redundant 800 tph crushers. Crushed material will be directed to dual 800 tph conveyors feeding Plant Surge Hopper No. 2 located at the units.

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Coal discharged from Plant Surge Hopper No. 2 will be directed to one of two 400 tph transfer conveyors provided with each unit, feeding a series of 400 tph cascade conveyors.

(8) Three plans were considered for the active storage equipment associated with this system. Costs for the alternate plans are presented below.

Comparative Costs	Plan A Dual Stacker/ Reclaimers $1,000	Plan B Traveling Stacker $1,000	Plan C Traveling Tripper $1,000
Total differential capital cost	Base	3,646	3,328

(9) The trencher type stacker/reclaimers of Plan A can be remotely operated from a control room at the Coal Crusher Building. If operators were required for the machines, operating costs would be equivalent to $2,960,000 in capital costs.

2.2 CONCLUSIONS

The coal handling system should be provided with dual trencher type stacker/reclaimers arranged generally as shown on Figures 3-3 and 3-4 (Plan A). Remote operation should be provided for the stockout and reclaim system including the stacker/reclaimers from an elevated control room in Crusher Building No. 2. No operators are required on the trencher type stacker/reclaimers.

If coal from Units 1 and 2 can be used for emergencies, then the area within the coal loop will not be needed for emergency coal storage.

3.0 ANALYSIS
COAL HANDLING SYSTEM

3.1 OBJECTIVE

The objective of this analysis is to determine the optimum coal handling system for Units 4 and 5 at the Crystal River Plant site.

3.2 REQUIREMENTS

The requirements of the system are as outlined below.

(1) The Units 4 and 5 stockout and reclaim system will receive coal from the existing barge unloading and railcar unloading facilities.

(2) Approximately 50 per cent of the coal required for Units 4 and 5 will be delivered to the plant site in 70 car unit trains consisting of 100-ton capacity cars. An average of four to six trains per week will be required to supply this amount assuming the present projections for plant capacity. Maximum unloading rate for this equipment is 2,500 tph.

The remaining 50 per cent of coal required for Units 4 and 5 will be transported to the plant site in ocean-going barges. The existing coal receiving facilities at the Crystal River Plant are designed for unloading barges with up to 13,000 short tons capacity. Based on Western coal, an average of about three barges per week will be required. The barge unloading system is designed for unloading at 1,500 tph maximum; however, field reports indicate that the average unloading rate is approximately 700 tph.

(3) The stockout and reclaim system will provide for the handling, storage, and blending of at least two types of coal. Complete segregation of the two coals is required prior to blending.

(4) Approximately 855,000 tons of reserve storage will be provided for 90 days fuel requirements for both units operating at 60 per cent capacity. This is to preclude unit downtime in the event of an interruption in coal supplies.

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(5) The stockout and reclaim system will provide 43,000 tons of active storage for 3 days fuel requirements for both units operating at 90 per cent capacity. Coal reclaimable by mobile equipment will not be considered as active storage.

(6) The maximum design burn rate for Units 4 and 5 is 330 tons per hour per unit or 660 tons per hour total, based on a design coal heating value of 10,285 Btu per pound.

(7) The coal silos for Units 4 and 5 will provide for 8 hours operation for each unit based on the maximum design burn rate.

(8) The coal crushing and silo fill system will provide for 100 per cent redundancy for all conveying and crushing equipment.

(9) All costs shown in the analysis shall include 20.5 per cent interest during construction and 8.7 per cent general indirect construction costs. All costs are 1982 costs.

3.3 SYSTEM DESCRIPTION

All plans considered in this analysis employ the same general plan arrangement as shown on Figure 3-1. Coal will be received by modifications and addition of equipment now serving Units 1 and 2. Coal is currently received at an existing barge dock and an existing railcar unloader.

Barge coal received at Transfer Point No. 1 will be conveyed by a modified Conveyor No. 2. Transfer Point No. 2 will divert the coal to an existing Conveyor No. 3-A, serving Units 1 and 2, or onto Conveyor No. 3-B. An additional transfer at Transfer Point No. 3 will receive coal from Conveyor No. 3-B and transfer it onto Conveyor No. 29 to a new Transfer Point No. 24.

Rail coal will be unloaded by the existing train unloader and conveyed to new Transfer Point No. 23 by modified Conveyor No. 11. Coal then may be diverted to the existing radial stacker or to converge with barge coal at Transfer Point No. 24.

Barge and rail coal received by Transfer Point No. 24 will be transferred by a 2,500 tph conveyor, Conveyor No. 30, to Transfer Point No. 25,

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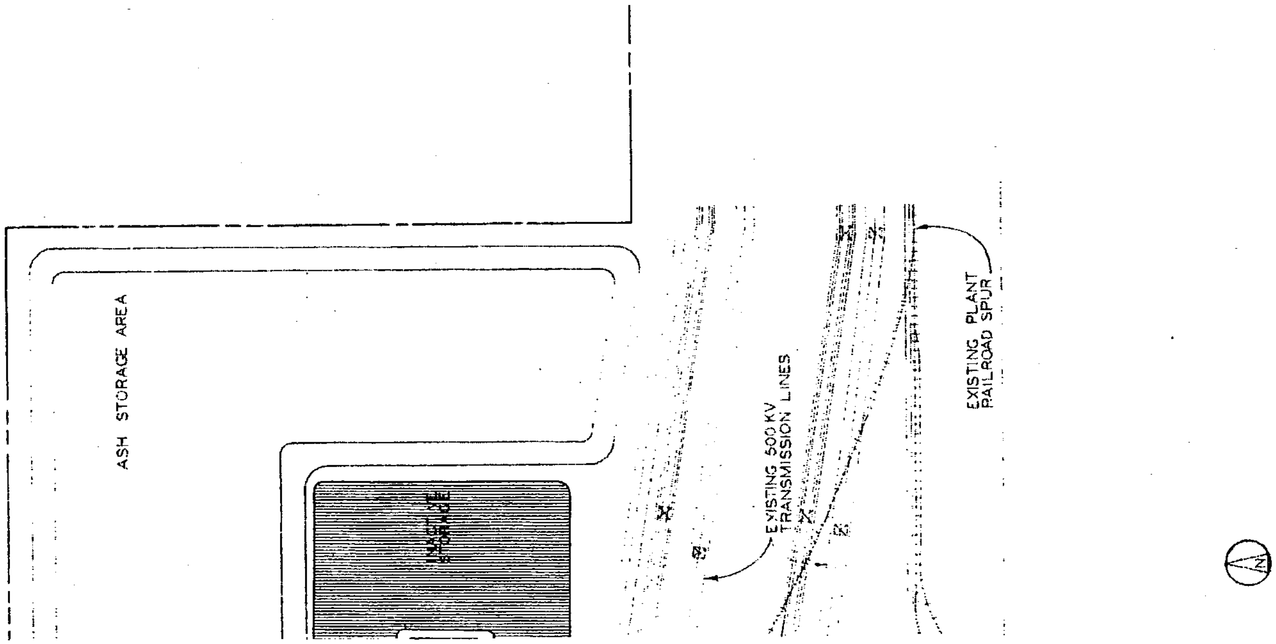

GENERAL PLAN ARRANGEMENT
FIGURE 3-1

located inside the railroad loop. At this point, the coal will be transferred to Conveyor No. 31, also 2,500 tph, and transferred to the north coal yard.

The general base plan has Conveyor No. 24 passing through a tunnel which will be constructed under the railroad track. The tunnel construction would require a curtailment of rail coal deliveries, which could be feasible if downtime was properly coordinated with plant operation and downtime is kept to a minimum.

The advantage of the general base plan is that the space within the railroad loop would be accessible by the conveyor system for emergency coal stockout and storage at a future date if required.

In the northeast area, coal arriving at Transfer Point No. 26 may be diverted to active storage on Conveyor No. 32 or to Transfer Point No. 27 on Conveyor No. 33, both 2,500 tph conveyors. In a like manner, at Transfer Point No. 27 coal may be diverted to active storage on Conveyor No. 34 or to dual 800 tph conveyors to Units 4 and 5 Coal Crusher House No. 2.

Each of the two crushers will have the capability of discharging crushed or internally bypassed material onto two 800 tph conveyors, which will transport and elevate the coal to a common surge hopper.

The Plant Surge Hopper No. 2 will have four outlets, with a working capacity of 180 tons and a receive and discharge rate of 1,600 tph. Coal is discharged through each outlet onto a vibratory feeder and then to a 400 tph transfer conveyor. The cascade conveyors, shown on Figure 3-2, receive the coal from the transfer conveyors. The cascade conveyor system was chosen over other silo filling systems due to its reliability, simple controls, and low cost.

The transfer of coal into the silos will be accomplished by the first cascade conveyor discharging into the first silo of the series until that silo is filled and then discharging to the next conveyor in sequence. The feed of coal from one cascade conveyor to the next will be accomplished by positioning diversion gates. The progressive filling and subsequent transfer action will continue through all conveyors and silos of that row until all the silos are filled. All cascade conveyors will be rated at 400 tph.

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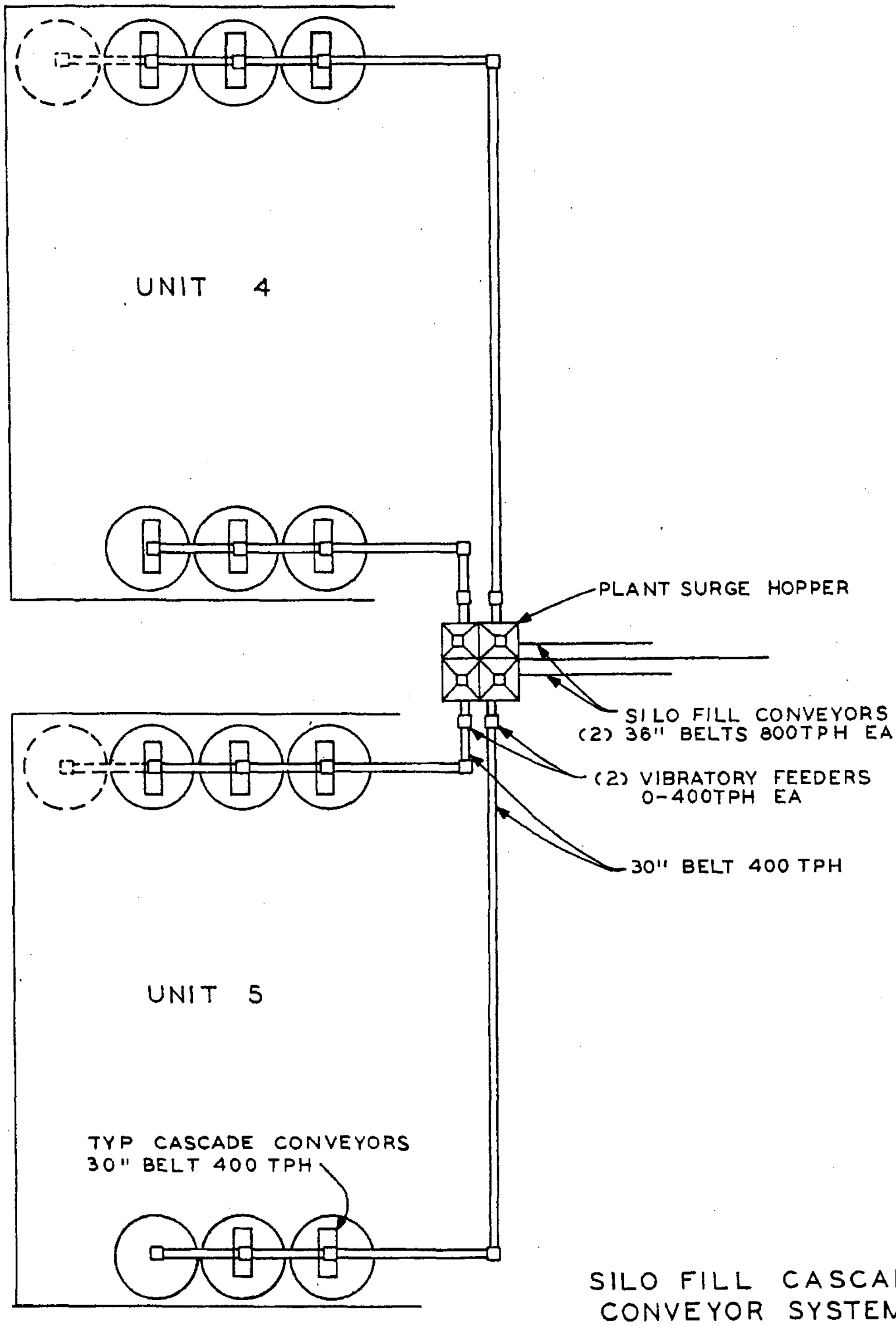

SILO FILL CASCADE CONVEYOR SYSTEM

FIGURE 3-2

P-GN-180B

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3.4 ALTERNATE PLANS

All plans discussed below will use the conceptual arrangement described in Section 3.3. The principal difference in the alternates proposed is the method and equipment used in stockpiling and reclaiming the coal from active storage.

The following equipment was considered for the active storage system.

(1) Plan A Dual Stacker/Reclaimers.

(2) Plan B Traveling Stacker, Rotary Plow Reclaim.

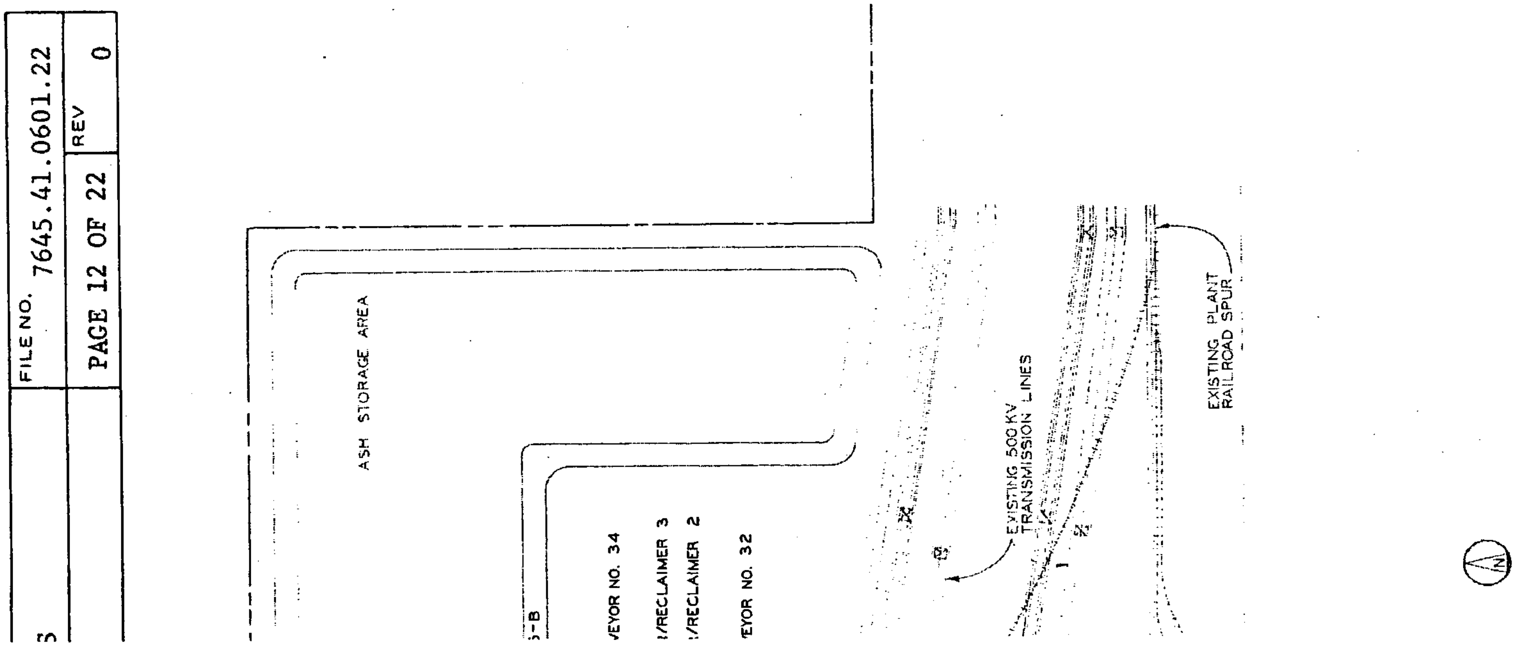
(3) Plan C Traveling Tripper, Rotary Plow Reclaim.

(4) Plan D Storage Silos.

3.4.1 Plan A Dual Stacker/Reclaimers

Plan A would employ dual stacker/reclaimers arranged as shown on Figure 3-3 to provide active storage for the units. At Transfer Point 26 the system would have the capability of splitting the flow of coal from Conveyor No. 31 between Conveyors No. 32 and 33. Conveyor No. 32 would be a 2,500 tph reversing yard belt feeding trenching type bucket wheel Stacker/Reclaimer 2. Conveyor No. 33 would lead to Transfer Point 27. In like manner, at Transfer Point 27 the system would be capable of splitting the flow of coal from Conveyor No. 33 between Conveyor No. 34 and either Conveyor No. 35A or 35B. Conveyor No. 34 would be a 2,500 tph reversing yard belt feeding trenching type bucket wheel Stacker/Reclaimer 3. Conveyors No. 35A and 35B would transport coal to Crusher Building No. 2. Coal directed to yard Conveyors No. 32 and 34 would be stocked out in the active storage piles of the stacker/reclaimers (21,500 tons each stacker/reclaimer) and eventually reclaimed by means of the associated bucket wheel as shown on Figure 3-4.

With this scheme blending would be accomplished as follows. During coal unloading, coal directed to Transfer Point 26, Coal A for example, would be split to both Conveyors No. 32 and 33. Coal on Conveyor No. 32 would be stocked out in the active storage piles of Stacker/Reclaimer 2. Coal on Conveyor No. 33 would be blended with Coal B reclaimed by Stacker/Reclaimer 3 and directed on to the units. Blending would occur on Conveyor No. 35A or 35B in Transfer Point No. 27.



PLAN A
DUAL STACKER/RECLAIMERS
FIGURE 3-3

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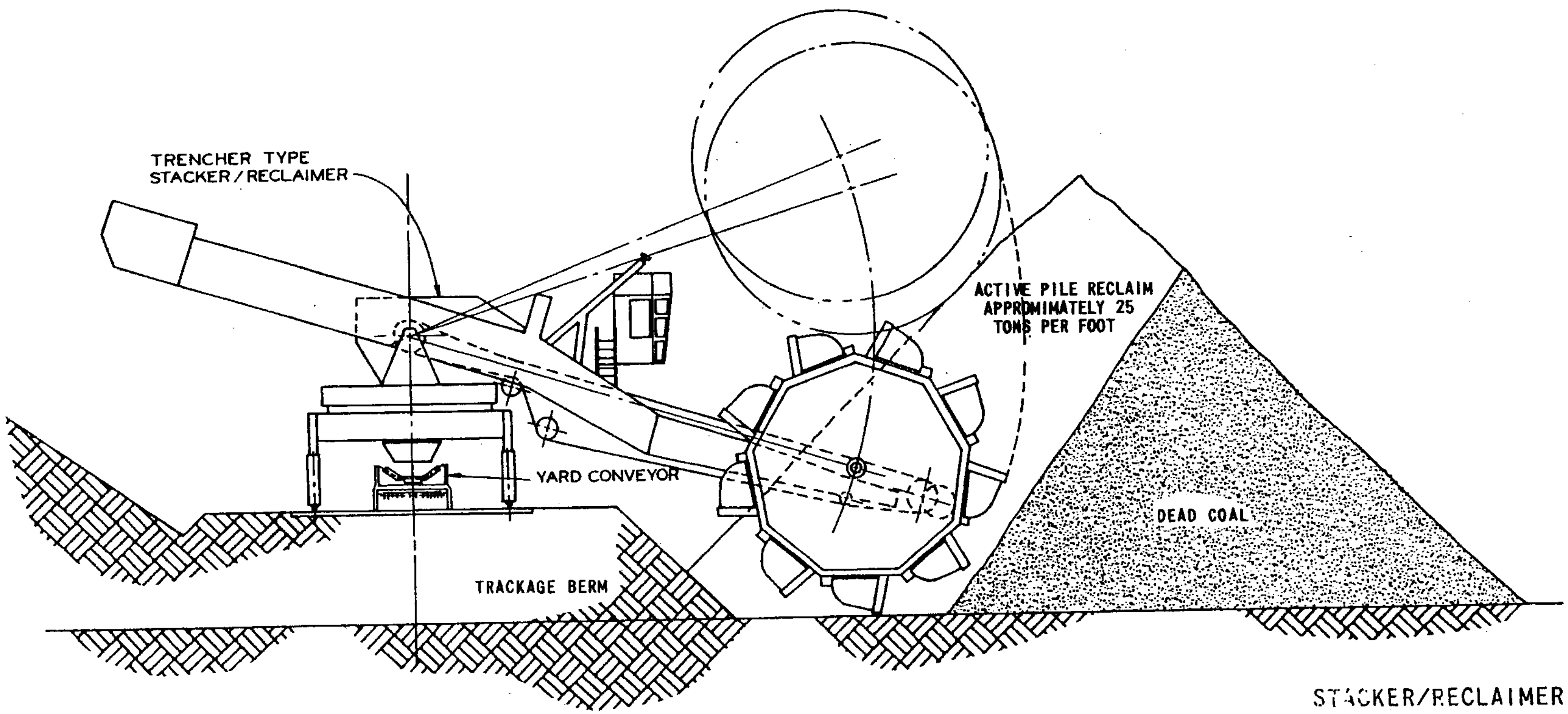

STACKER/RECLAIMER
CROSS SECTION

FIGURE 3-4

SYSTEM ANALYSIS

COAL HANDLING

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Coal Handling System Analysis
Exhibit No. _____ (JAB-18)

When a train or barge is unavailable, blending would be accomplished in the same manner with Coal A being supplied from Stacker/Reclaimer 2.

The disadvantage of Plan A lies in the fact that if either stacker/reclaimer is down, the system no longer has blending capability, unless the Units 1 and 2 facilities or the unloading facilities are used to regulate the flow of the coal delivered to Transfer Point 26 to a value compatible with the blending ratio. This problem could be alleviated to some extent by stockpiling quantities of blended coal in the active and reserve storage piles and reclaiming with the stacker/reclaimer still in service. However, the stockpiling operation would have to be curtailed while the stacker/reclaimer reclaims blended coal for the unit silos. Blending could be accomplished with one stacker/reclaimer if the rate required for the blend could be produced by the unloading facilities without affecting the unloading rate.

Each stacker/reclaimer will have two types of coal in its active storage area.

3.4.2 Plan B Traveling Stacker, Rotary Plow Reclaim

With Plan B, coal directed to Transfer Point 26 would be conveyed to active storage by Conveyors No. 32A and 33 rated at 2,500 tph and would be stocked out by means of a traveling stacker as shown on Figure 3-5. Coal would be reclaimed by means of two rotary plow feeders as shown on Figure 3-6, both feeding 1,600 tph Conveyor No. 34. Conveyor No. 34 would return the coal to Transfer Point 26 for delivery to Coal Crusher Building No. 2. Two types of coal will be stocked in separate piles so blending can be accomplished by the two plow feeders.

In addition to the equipment mentioned, Plan B would require an additional emergency reclaim structure to prevent unit outage in the event of mechanical failure of Conveyor No. 34. The emergency reclaim structure would feature a rotary plow and associated structure similar to that shown on Figure 3-6 but with less traverse distance required.

During train or barge unloading, blending would be accomplished by splitting the coal flow at Transfer House 26 between the traveling stacker and either Conveyor No. 35A or 35B. The required amount of the other coal

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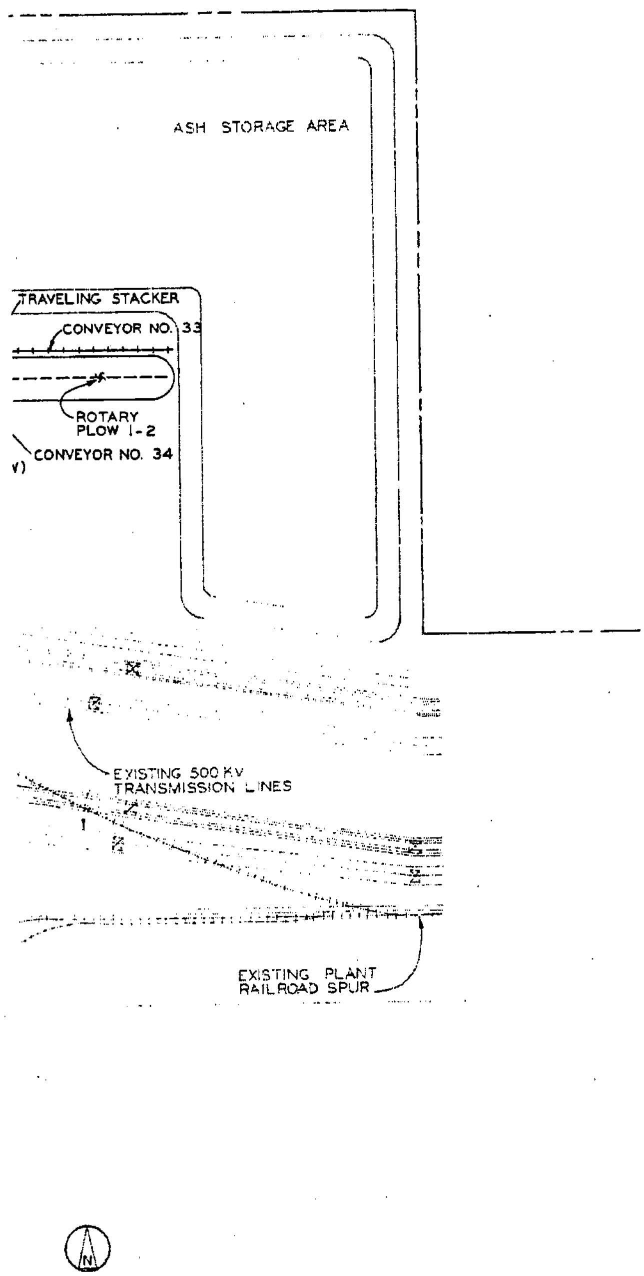
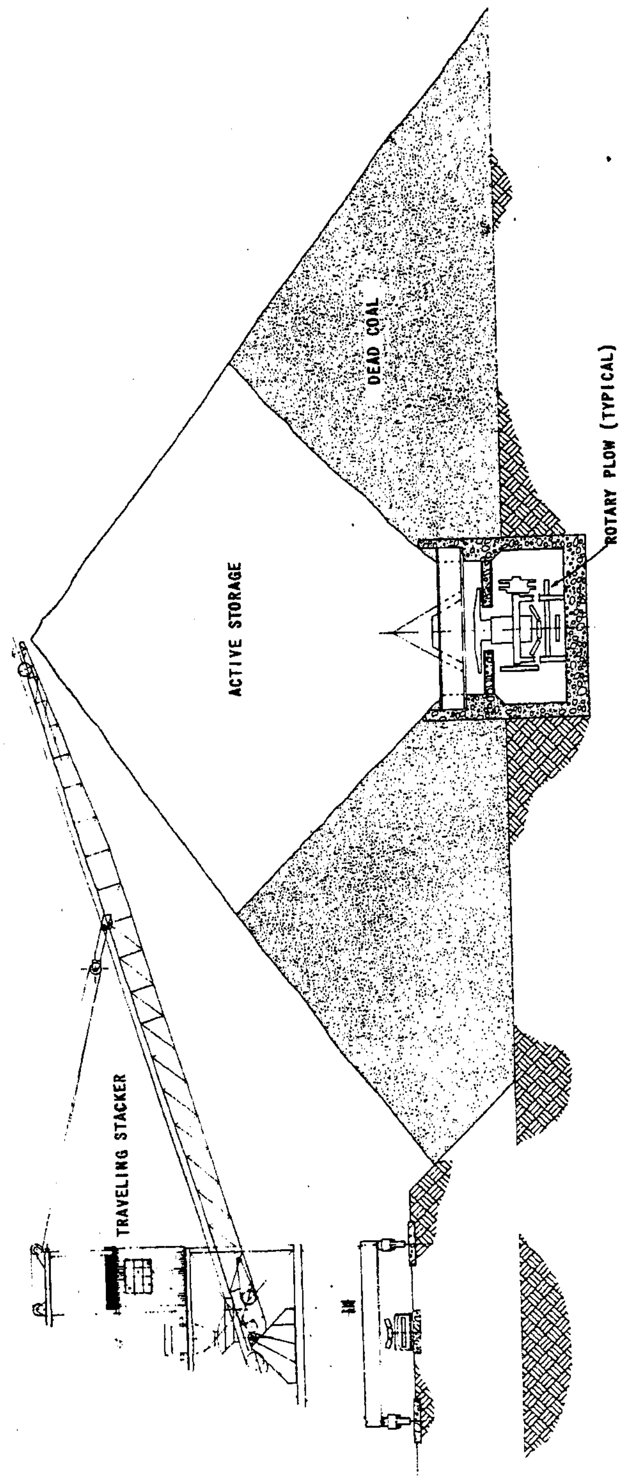


PLAN B
TRAVELING STACKER
ROTARY PLOW RECLAIM
FIGURE 3-5

	SYSTEM ANALYSIS	FILE NO. 7645.41.0601.22	
	COAL HANDLING	PAGE 16 OF 22	REV 0



TRAVELING STACKER
CROSS SECTION

FIGURE 3-6

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type would simultaneously be reclaimed by either of the rotary plows and blended with the coal directed onto Conveyor No. 35A or 35B.

In the event no coal is available at the unloading facility, one coal type would be reclaimed by each of the rotary plows and blended directly on Conveyor 34.

Plan B has the additional advantage that the chutework of Transfer Point 26 could be arranged to allow the system to stockpile blended coal without the use of the Units 1 and 2 unloading facilities as a source for the blend. This could be done by providing Conveyors No. 34 and 32B with the capability of discharging onto Conveyor No. 32A and thus blending at Transfer Point 26 by means of the rotary plows and/or emergency reclaim structure. A section of the storage pile could then be dedicated to blended coal for either emergency or routine usage. If one rotary plow is inoperative, blending could be accomplished using the emergency reclaim system and the other rotary plow.

3.4.3 Plan C Traveling Tripper, Rotary Plow Reclaim

Plan C, shown on Figure 3-7, would be similar to Plan B in that both plans utilize two rotary plows for reclaiming coal.

With Plan C, however, coal directed to Transfer Point 26 would be conveyed to active storage by Conveyors No. 32 and 34 and stocked out by an enclosed traveling tripper or bypassed by the tripper to the fixed boom stockout at the end of the belt as shown on Figure 3-8. Rotary Plow 1-1 would reclaim onto Conveyor No. 33A and Rotary Plow 1-2 would reclaim onto Conveyor No. 33B. Both Conveyors No. 33A and 33B would elevate coal to Transfer Point No. 26 for delivery to the Coal Crusher Building. Each half of the active storage would be dedicated to a coal used for blending.

As shown on Figure 3-9, the entire active storage pile would be enclosed by the tripper structure. This arrangement would eliminate the fugitive dust emission problems normally encountered in stockpile operations. The enclosed storage area will be made accessible to dozing coal from the inactive storage area by means of overhead doors on the side of the tripper structure.

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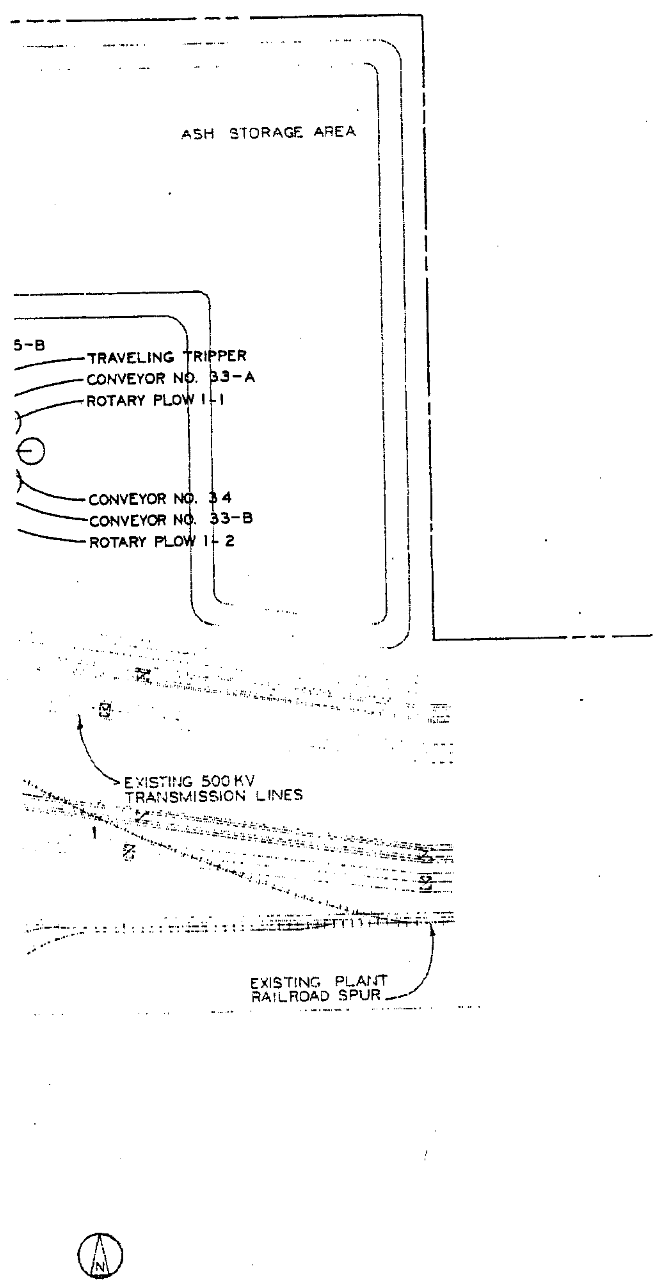

PLAN C
TRAVELING TRIPPER
ROTARY PLOW RECLAIM
FIGURE 3-7

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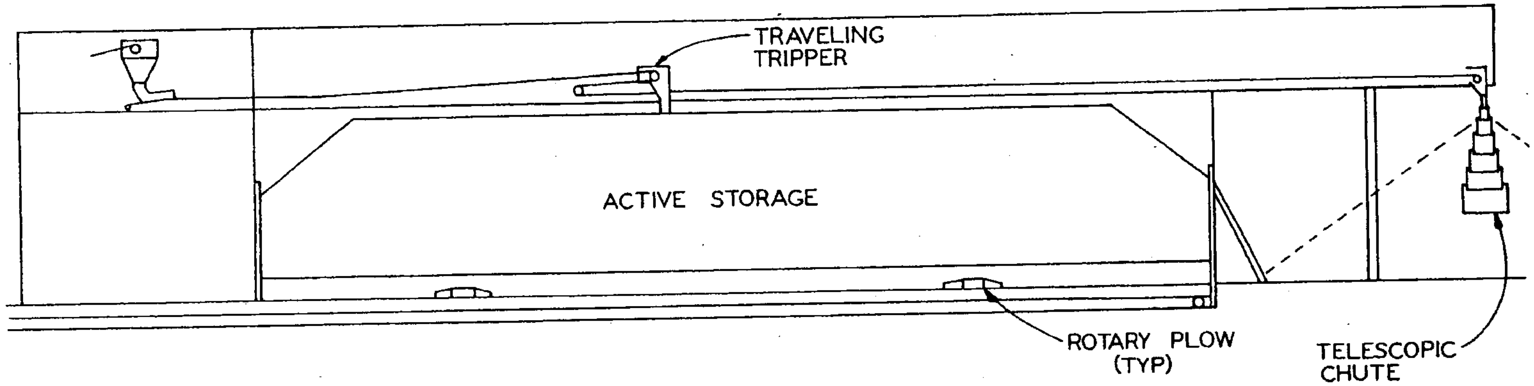
FPC-7/15/80



PLAN C
TRAVELING TRIPPER
ROTARY PLOW RECLAIM

FIGURE 3-8

SYSTEM ANALYSIS
COAL HANDLING
FILE NO. 7645.41.0601.22
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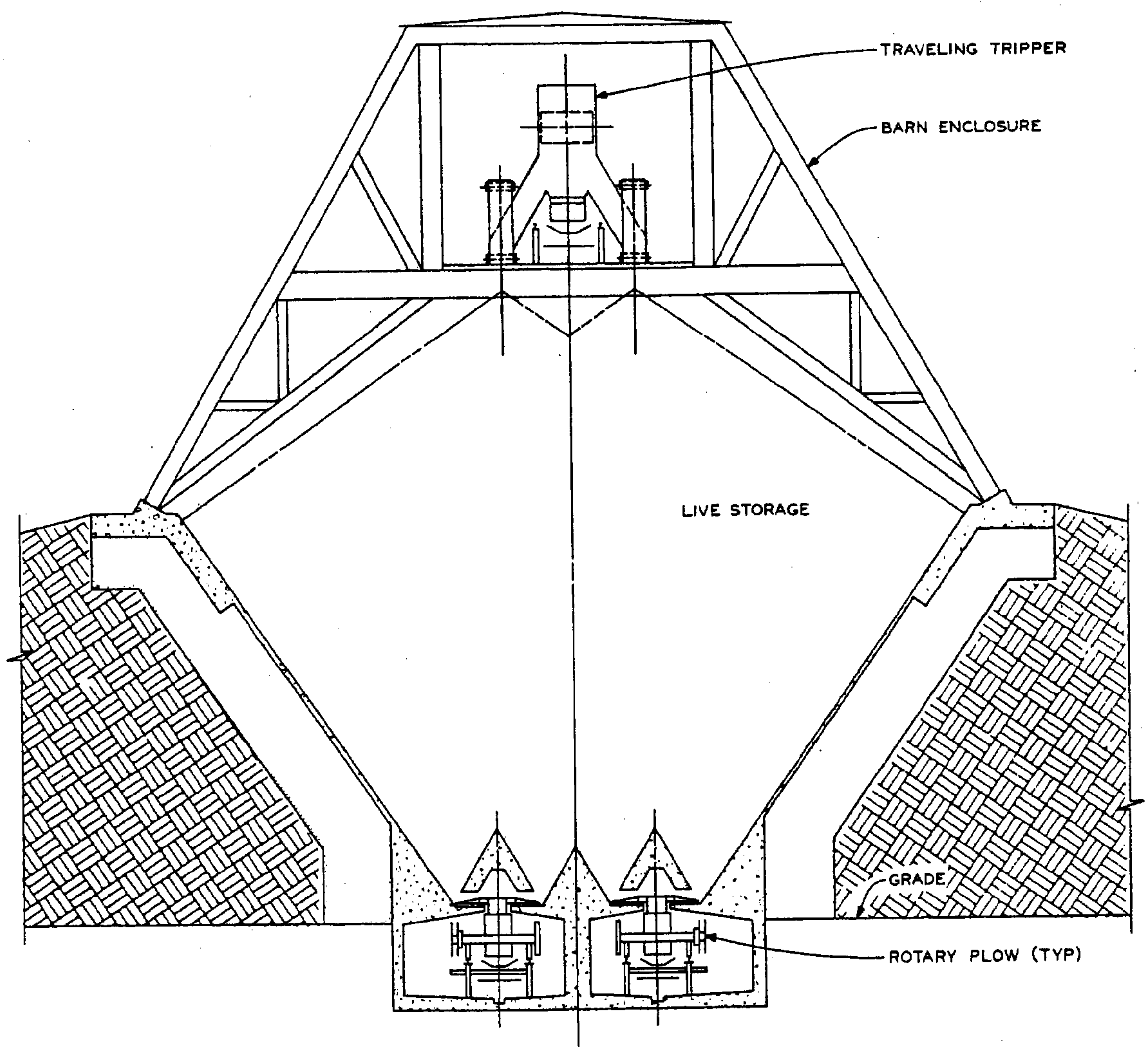

PLAN C
TRAVELING TRIPPER
ROTARY PLOW RECLAIM
SECTION

FIGURE 3-9

3.4.4 Plan D Storage Silos

An analysis was conducted of the stockout system with four aboveground storage silos, a fixed boom stockout and rotary plow reclaim structure for development and reclaim of the reserve piles. It was determined that for the capacities involved the total cost would be prohibitive and for this reason no further consideration was given to this alternative.

3.5 CAPITAL COSTS

The capital cost for the alternative plans described are presented in Table 3-1. The costs shown are current costs and include 8.7 per cent general indirect costs and 20.5 per cent interest during construction. All plans include only the capital cost for the active storage equipment associated with each arrangement.

All plans have comparable costs of operation assuming operators are not required for the stacker/reclaimers of Plan A. Operation of coal yard stockout and reclaim systems including the stacker/reclaimers would be from a remote elevated control room located in Transfer Structure 26 or 27 depending on the plan adopted.

Some utilities operating elevating type stacker/reclaimers have found that an operator is required on the machine. For this reason, only trencher type stacker/reclaimers were considered in Plan A. The trencher machine is simpler and can be operated successfully from a remote location.

If operators were required for the stacker/reclaimer of Plan A, the additional costs in terms of equivalent capital would be $2,960,000 for two-shift operation (six operators total).

TABLE 3-1. STOCKOUT & RECLAIM SYSTEM CAPITAL COSTS

Costs	Plan A Dual Stacker/ Reclaimers	Plan B Traveling Stacker	Plan C Traveling Tripper
	$1,000	$1,000	$1,000
Conveyors	4,751	5,615	5,562
Stacker/reclaimers	4,412	--	--
Traveling stacker	--	852	--
Traveling tripper and support structure	--	--	2,260
Rotary plows and reclaim structure	--	4,054	3,709
Emergency reclaim structure	--	1,205	--
Fire Protection	1,108	1,137	1,100
Dust collection	969	1,173	1,732
Mechanical	603	646	688
Structural	1,252	1,252	1,252
Electrical	275	462	406
Subtotal	12,401	15,223	14,977
Interest during construction @ 20.5 per cent	2,542	3,121	3,070
General indirect construction cost @ 8.7 per cent	1,079	1,324	1,303
Total capital cost	16,022	19,668	19,350
Total differential capital cost	Base	3,646	3,328

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SYSTEM DESIGN SPECIFICATION	FILE NO. 7645.42.0702.12
PRECIPITATOR	REV 0

RPORATION TYPICAL ANALYSES AS-RECEIVED BASIS (Values in Parentheses are on a Dry Coal Basis)

	(1) Eastern Province Ala., E. Ky., Tenn., Southern W. Va.				(2) Utah				(3) Colorado				(4) Wyoming			
	Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum
	7.0		4.0	12.0	7.0		4.0	12.0	12.0		8.0	16.0	21.5		18.0	24.0
	30.0		(28.0)	--	39.8		--	--	35.4		--	--	32.5		--	--
	53.0		--	--	46.2		--	--	46.6		--	--	40.0		--	--
	10.0		--	(16.0)	8.0		(5.0)	(16.0)	6.0		(4.0)	(12.0)	6.0		(3.0)	(12.0)
	69.0		--	--	69.2		--	--	64.0		--	--	55.5		--	--
	4.4		--	--	5.1		--	--	4.6		--	--	3.9		--	--
	1.4		--	--	1.4		--	--	0.7		--	--	0.8		--	--
	7.65		--	--	8.55		--	--	12.29		--	--	11.75		--	--
	0.50		--	0.8	0.7		(0.4)	(1.0)	0.4		(0.3)	(0.8)	0.5		(0.3)	(1.0)
	0.05		--	(0.15)	0.05		(0.02)	(0.10)	0.01		(0.01)	(0.06)	0.05		(0.01)	(0.05)
b	12,450		11,000	13,000	12,000		10,500	12,500	11,275		10,000	12,000	9,650		9,200	11,000
:	45		38	65	45		40	56	49		44	55	50		44	55
	Red.	Oxid.	Reducing		Red.	Oxid.	Reducing		Red.	Oxid.	Reducing		Red.	Oxid.	Reducing	
	2250	2350	--	--	2130	2210	--	--	2460	2470	--	--	2100	2130	--	--
	2300	2400	2200	2700+	2230	2350	2000	2600	2465	2500	2200	2700+	2280	2310	2120	2650
	2330	2440	--	--	2250	2390	--	--	2470	2540	--	--	2440	2480	--	--
	2350	2475	--	--	2340	2500	--	--	2520	2600	--	--	2600	2650	--	--
	45.0		--	--	47.2		--	--	37.5		--	--	49.8		--	--
	24.0		--	--	22.4		--	--	28.4		--	--	16.8		--	--
	1.0		--	--	1.1		--	--	1.3		--	--	0.5		--	--
	8.0		--	18.0	5.8		--	--	4.7		--	--	6.9		--	--
	10.5		--	--	10.6		--	--	9.6		--	--	8.3		--	--
	2.0		--	--	0.8		--	--	3.3		--	--	4.6		--	--
	0.50		--	0.80	4.5		2.0	6.0	2.5		0.4	3.0	0.2		0.1	1.0
	1.50		--	--	0.4		--	--	0.6		--	--	0.5		--	--
	6.0		--	--	6.2		--	--	10.7		--	--	10.3		--	--
	0.40		--	--	0.5		--	--	0.6		--	--	0.6		--	--

(5) Wyoming				(6) New Mexico				(7) Wyoming				(8) Southern W. Va.			
Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum	Typical		Range Minimum	Range Maximum
12.0		9.0	15.0	15.0		12.0	21.0	30.0		27.0	32.0	7.0		4.0	9.0
37.0		--	--	35.4		--	--	32.1		--	--	33.8		--	--
41.0		--	--	38.8		--	--	32.1		--	--	--		--	--
10.0		(7.0)	(15.0)	10.8		(10.0)	(20.0)	5.8		(6.5)	(11.0)	8.2		(8.0)	(10.0)
60.0		--	--	55.7		--	--	48.50		--	--	68.5		--	--
4.1		--	--	4.1		--	--	3.40		--	--	5.0		--	--
0.9		--	--	1.0		--	--	0.70		--	--	1.9		--	--
12.37		--	--	12.78		--	--	11.10		--	--	0.02		(0.01)	(0.09)
0.6		(0.3)	(1.0)	0.6		(0.5)	(1.2)	0.48		--	--	0.60		(0.50)	(0.79)
0.03		(0.01)	(0.05)	0.02		(0.02)	(0.06)	0.02		(0.01)	(0.06)	9.18		--	--
10,000		9,500	10,500	9,700		8,750	10,000	8,125		7,700	8,600	12,500		12,000	13,000
47		42	52	45		40	48	52		50	60	42			
Red.	Oxid.	Reducing		Red.	Oxid.	Reducing		Red.	Oxid.	Reducing		Red.	Oxid.	Reducing	
2070	2100	--	--	2280	2399	--	--	2060	2070	--	--	2750+		--	--
2155	2320	2080	2300	2400	2510	2250	2700+	2120	2160	2000	2300				
2200	2340	--	--	2440	2535	--	--	2140	2180	--	--				
2245	2420	--	--	2520	2620	--	--	2180	2220	--	--				
38.0		--	--	53.6		--	--	34.0		--	--	52.9		--	--
23.9		--	--	22.7		--	--	13.0		--	--	35.4		--	--
0.9		--	--	1.0		--	--	1.0		--	--	1.0		--	--
9.5		--	--	5.4		--	--	6.0		--	--	4.0		--	--
13.2		--	--	4.3		--	--	20.0		--	--	0.9		--	--
3.5		--	--	1.5		--	--	6.0		--	--	1.3		--	--
0.4		0.3	3.0	2.0		0.2	3.0	2.8		1.0	4.0	0.22		--	--
1.3		--	--	1.1		--	--	0.8		--	--	2.60		--	--
9.0		--	--	6.3		--	--	13.7		--	--	0.04		--	--
0.8		--	--	0.1		--	--	2.0		--	--	0.34		--	--

TABLE 2-4. PRECIPITATOR FUNCTIONAL CONSTRAINTS

Parameter	Value
Maximum dust loading at outlet, grains/DSCF	0.015
Minimum number of fields in the direction of gas flow	5
Minimum total kVA rating of transformer-rectifiers	5,000
Maximum gas velocity through precipitator, at design flow conditions, fps	4.0
Minimum specified collecting area, square feet per 1,000 acfm (based on design flow conditions)	700
Maximum pressure drop, in. H_2O	
Through precipitator	0.5
Through ductwork and gas distribution devices	1.5
Hopper minimum storage capacity, each hopper, with design flow conditions and maximum inlet dust loading, hours	12

TABLE 2-5. PRECIPITATOR PHYSICAL CONSTRAINTS

Parameter	Value
Maximum length of discharge electrodes, feet	45
Maximum height of collecting surfaces, feet	45
Minimum aspect ratio (effective length/effective height)	2.0
Minimum effective treatment length, feet	63
Minimum number of transformer-rectifier sets	80
Minimum hopper valley angle, degrees from horizontal	55