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February 28, 1997

R. Douglas Neeley, Chief  
Air and Radiation Technology Branch  
Air, Pesticides, and Toxics Management Division  
U.S. Environmental Protection Agency  
Atlanta Federal Center  
100 Alabama Street, SW  
Atlanta, GA 30303-3104

RE: Review of Information Related to FPC's Request to Co-fire Petroleum Coke with  
Coal in Crystal River Units #1 and #2

Dear Mr. Neeley:

This letter is intended to follow-up on issues raised in EPA Region IV's February 14, 1997 letter to the State of Florida Department of Environmental Protection (DEP) and Florida Power Corporation's (FPC's) February 18, 1997 response.

Regarding the issue of whether petroleum coke was contemplated as a fuel in the original design of Crystal River Units 1 and 2 or in the coal reconversion, I have enclosed two documents for your review. Attachment 1 consists of excerpts from Combustion Engineering. A Reference Book on Fuel Burning and Steam Generating, Fryling (Ed.). This book was published in 1967 by Combustion Engineering, Inc., the same company that originally designed and manufactured the boilers and associated appurtenances for Crystal River Units 1 and 2. As you will see, Combustion Engineering's reference book addresses "the important fuel properties and end uses in boiler firing" of by-product fuels such as "petroleum coke." Petroleum coke is specifically discussed on page 14-19; in Table 14-19, the "equipment utilized" to generate steam with petroleum coke includes "tangential burners" and pulverizers. Crystal River Units 1 and 2, when installed in the mid-1960s, were equipped with Combustion Engineering boilers with tangential burners. In Table 16-2, Combustion Engineering's reference book lists petroleum coke as suitable for being pulverized in the same type of mill equipment installed at

R. Douglas Neeley, Chief  
February 28, 1997  
Page 2

Crystal River. I am hopeful that this documentation conclusively confirms that petroleum coke was "designed into" the original construction of Crystal River Units 1 and 2. (As previously explained, FPC believes that this level of detailed design information is not required to qualify for the PSD exemption. I am providing it to demonstrate that such documentation does, in fact, exist.)

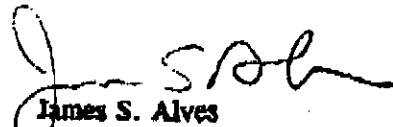
Attachment 2 is a September 28, 1976 memorandum from Combustion Engineering addressing FPC's interest in co-firing petroleum coke with coal. This correspondence preceded FPC's December, 1976 resumption of coal-fired operations in Unit 2. As you will see, this memorandum concludes co-firing petroleum coke with coal could be accomplished (at a substantially higher blend rate than FPC currently proposes), and specifically suggests several blending options that require no additional equipment or physical alteration to existing equipment. These blending options existed prior to January 6, 1975 and continue to be available today. This document reconfirms that with the reconversion to coal, petroleum coke remained an inherent fuel alternative specifically designed into the source.

I trust that the specific information provided on the first page of FPC's February 18, 1997 letter addressed any concerns as to whether the coal/petcoke blend that FPC proposes to utilize is equivalent, in all material respects (relating to PSD applicability) with the coal that FPC typically utilizes.

We are following-up on your February 14 letter because its conclusion was premised on EPA's observations that "there is no information submitted to date that indicates that petcoke was contemplated as a fuel in the original design or in the coal conversion," and "it is not clear that blending capability to co-fire coal and petcoke was present prior to 1975." Hopefully, EPA now will concur that it has the requisite information and that any lack of clarity has been resolved.

We would appreciate your expeditious consideration of these materials.

Very truly yours,



James S. Alves  
Attorney for Florida Power Corporation

cc: Brian Beals  
Howard Rhodes  
Doug Beason

# COMBUSTION ENGINEERING

A REFERENCE BOOK ON FUEL BURNING AND STEAM GENERATION

GLENN R. FRYLING, M.E.

*Editor*

REVISED EDITION  
SECOND IMPRESSION

PUBLISHED BY  
**COMBUSTION ENGINEERING, INC.**  
277 PARK AVENUE, NEW YORK 10017  
1967

Attachment 1

# 14

## Natural Gas, Oil and Byproduct Fuels<sup>1</sup>

Fossil fuels may be classified as in Table 14-1 into solid, liquid and gaseous fuels. Each of these fuels may in turn be further classified as natural fuels and manufactured or byproduct fuels. These classifications are not mutually exclusive and necessarily overlap in some areas.

Obvious examples of natural fuels are coal, crude oil and natural gas. Residual oils which are fired in boilers might be

considered as a byproduct of the refining of crude oil. Wood, although a natural fuel, is rarely burned in boilers except in the form of sawdust, shavings, slabs and bark which remain as a byproduct after lumbering and pulping operations. Coal is the natural fuel from which coke, coke oven gas, char, tars, chemicals and industrial gases may be converted by carbonization. Coal may also be gasified to

Table 14-1 Classification of Fuels

Type of Fuel	Natural Fuels	Manufactured or Byproduct Fuels
Solid	Coal  Lignite Peat Wood	Coke and coke breeze Coal tar Lignite char  Charcoal Bark, saw dust and wood waste Petroleum coke Sugarcane Refuse
Liquid	Petroleum	Gasoline Kerosene Fuel oil Gas oil Shale oil Petroleum fractions and residues
Gaseous	Natural gas Liquefied petroleum gases (LPG)	Refinery gas Coke oven gas Blast furnace gas Producer gas Water gas Carbonized water gas Coal gas Sugarcane waste gas

<sup>1</sup> Information from First Edition revised and supplemented by D. J. Fray.

## 14-2 COMBUSTION ENGINEERING

obtain industrial gases for heating, chemical reduction, and hydrogenation and synthesis reactions.\*

In this book fuels are discussed primarily from the point of their usefulness and economic utilization in the generation of steam. Since coal is the most important fuel fired in boilers, the preceding chapter, Fuel Properties of Coal, is appropriately devoted to it. Yet the reader must not lose sight of the increasing contribution of natural gas and crude petroleum to the energy market of the United States as shown graphically in Fig. 14-1 for the years 1900 through 1960. More than any-



Fig. 14-1. Changes in United States energy production, 1900-1960

thing else this reflects the greatly increased use of petroleum products for automotive and aviation industries, plus the widespread consumption of oil and natural gas as domestic and industrial fuels.

This chapter is organized in major sections dealing with gaseous, liquid and solid fuels. Discussions of natural, manufactured and byproduct fuels are interspersed throughout the chapter, together with mention of important fuel properties

and end uses in boiler firing. The chapter title was chosen to focus attention upon natural gas, oil and byproduct fuels and to emphasize their importance as sources of thermal energy for steam generation.

### Gaseous Fuels

Gaseous fuels are ideally suited for steam generation purposes because of the ease of control, the presence of little or no solid residue and the low excess air requirement which contributes to high efficiency.

Properties of fuel gas considered to be of prime importance are composition, heating value, and specific gravity.

### Analysis

The analysis of fuel gas is expressed in terms of volume percentages of the component gases. Determinations can be made by selective absorption in chemical solutions, by separation of components through distillation, by infrared or mass spectrometry, or by means of gas chromatography. Typical analysis of various gases are given under their specific headings.

### Heating Value

The heating value refers to the quantity of heat released during combustion of a unit amount of fuel gas. Determinations are made with a continuous flow (constant pressure) gas calorimeter. The heating value as determined in calorimeters is termed *higher heating value* and is the quantity of heat evolved when the products of combustion are cooled to 60 F and the water vapor produced is completely condensed to a liquid at that temperature. The *lower heating value* is the same as

\* For what might be described as a classic treatment of this subject, see Chapter II, Fuels, in *Steam Power Plant Engineering* by G. F. Gebhardt, Sixth Edition, 1926 Revision, John Wiley & Sons, New York; an authoritative approach of more recent origin may be found in the chapter, Fuels and Their Utilization, by Richard C. Corey from *Riegel's Industrial Chemistry*, edited by James A. Kent and published by Reinhold, New York, 1962.

NATURAL GAS, OIL AND BYPRODUCT FUELS 14-19

**Coke Breeze**

A certain amount of degradation occurs in the handling of coke; the resultant fines which pass through a  $\frac{1}{8}$  inch sieve are termed *coke breeze*.

**Petroleum Coke**

*Petroleum coke* is a byproduct of a process in which residual hydrocarbons are converted to lighter, more highly valued distillates. Two processes are in use: *delayed coking* and *fluid coking*.

**Delayed Coking.** In this process the reduced crude oil is heated rapidly and flows to isolated coking drums where it is coked by its own contained heat. The process requires several drums to permit removal of the coke in one drum while the others remain on stream. The residual product which solidifies in these drums is termed "delayed coke." When first removed from the drum it has the appearance of run-of-mine coal, except that the coke is dull black.

The analysis of the coke varies with the crude from which it is made. The components range as follows:

Moisture	3-12 per cent
Volatile matter	10-20 per cent
Fixed carbon	88-71 per cent
Ash	0.2-3.0 per cent
Btu per lb (Dry)	14,100-15,600
Sulfur	2.9-5.4 per cent

**Fluid Coking.** Two large vessels are used in fluid coking. One is known as a reactor vessel, and the other, a burner vessel. In this process, fluid coke is both the catalyst and secondary product. The seed coke is first heated in the burner vessel, either by adding air and burning a portion of the coke, or by burning an extraneous fuel such as oil. The heated seed coke then flows into the reactor vessel where it comes in contact with the pre-

heated residual oil and the lighter fractions of the oil are flashed off. The coke which is produced both deposits in uniform layers on the seed coke and forms new seed coke. Thus there is a constantly accumulating coke reservoir which is tapped off and is available as a boiler fuel.

The coke thus formed is a hard, dry, spherical solid resembling black sand. It is composed of over 90 per cent carbon with varying percentages of sulfur and ash, depending on the source of the crude oil. Typical analyses are as follows:

Fixed carbon	90-95 per cent
Volatile matter	5-6.5 per cent
Ash	0.2-0.5 per cent
Sulfur	4.0-7.5 per cent
Btu per lb, higher	14,100-14,600

**Coal Tar**

*Coal tar* is a byproduct in the carbonization of coal. The tar compounds are extremely complex and number in the hundreds. The solid material which is insoluble in benzene is contained as colloidal and coarse dispersed particles and is known as "free carbon." The composition of the tar is dependent on the temperature of carbonization and, to a lesser extent, on the nature of the coking coal. The following is an example of coal tar analysis and its physical properties:

Carbon	per cent	89.9
Hydrogen	per cent	6.0
Sulfur	per cent	1.2
Oxygen	per cent	1.8
Nitrogen	per cent	0.4
Moisture	per cent	0.7
Gravity	deg Baumé	1.18
Viscosity at 122 F	SSF	900
Flash point	F	156
Heating Value	Btu per lb	16,750

Coal tar is burned in boilers only when it cannot be sold for other purposes at a

## 14 - 24. COMBUSTION ENGINEERING

to supply heat from some other source if the wet material is to be disposed of in a boiler furnace."

**Hog Fuel.** In the manufacture of lumber the amount of material removed from the log to produce sound lumber is approximately as follows: 18 per cent in the form of slabs, edging and trimming; 10 per cent as bark; and 90 per cent as sawdust and shavings. While the total waste material will usually average 50 per cent, distribution of different types of waste may vary widely from the approximations given above, owing to mill conditions as well as finished product. The mills frequently use either the sawdust or a mixture of sawdust and shavings for steam production purposes, because these can be burned without further processing. The remainder of the so-called waste products requires further size reduction in a "hog" to facilitate feeding, rapid combustion, transportation and storage. These newly sized products, together with varying percentages of sawdust and shavings present, constitute *hog fuel*. The percentage of sawdust and shavings present may be quite high if the fuel is to be burned at the sawmill. Table 14-16 on page 14-22 shows typical analyses of hogged fuel.

One of the large paper producers conducted a series of tests to determine the moisture content, as well as the unit weight, of waste wood produced in his mill. The results of these tests, shown in Table 14-17, are an illustration of the wide variation in weight that will exist between units of hog fuel because of moisture and different wood-species content.

Hog fuel, as normally delivered to the furnace, contains variable amounts of moisture, which may be taken as approximately 50 per cent, and most of which is in the cellular structure of the wood.

Storage of logs in the mill pond, water lubrication of saws and exposure to rain due to outdoor storage of the hog fuel all contribute to the high total moisture content. In addition, the hog fuel, on dry-wood basis, contains approximately 81 per cent volatile matter and somewhat less than 18 per cent fixed carbon. The non-combustible residue, in the form of wood ash, is only a small fraction of one per cent.

**Bagasse**

*Bagasse* is a refuse of cane from which the sugar juice has been extracted. It has a fibrous structure like that of wood, and also a similar analysis. The most variable item is moisture, which normally ranges from 40 to 60 per cent. The relatively high ash in bagasse is due to silt picked up in the harvesting of the cane. Examples of bagasse from various countries are given on page 14-23 in Table 14-18.

**Fuel Burning Applications**

Emphasis in this chapter and in the preceding chapter on coal has been primarily placed upon fuel properties. Equipment design must necessarily be related to these fuel properties and is discussed in many sections of this book. Chapter 16 deals with the pulverization of solid fuels and Chapter 18 with their firing by means of stokers. The fuel burning systems discussed in Chapter 17 are capable of handling solid, liquid, and gaseous fuels.

Chapters 23 through 29 all provide examples of boilers in which the various fuels can be burned to generate steam. In addition, Table 14-19 lists many byproduct fuels and waste gases and tells how they are utilized and where additional information may be found.

<sup>11</sup> See Chapter 27, Boilers and Recovery Units for Pulp and Paper Industry, section on burning wood waste and bark, for additional information.





16-12 COMBUSTION ENGINEERING

Table 16-2 Types of Pulverizers for Various Materials

Type of Material	Ball or Tube	Impact and Attrition	Roll Mills	Ring Roll
Low volatile anthracite	x	-	x	-
High volatile anthracite	x	-	x	-
Coke breeze	x	-	x	x
Petroleum coke (fluid)	x	-	x	-
Petroleum coke (delayed)	x	x	x	x
Graphite	x	-	x	x
Bituminous coal (low volatile)	x	x	x	x
Bituminous coal (medium volatile)	x	x	x	x
Bituminous coal H.V. "A"	x	x	x	x
Bituminous coal H.V. "B"	x	x	x	x
Bituminous coal H.V. "C"	x	-	x	x
Subbituminous coal "A"	x	-	x	x
Subbituminous coal "B"	x	-	x	x
Subbituminous coal "C"	-	-	x	x
Lignite	-	-	x	x
Lignite and coal char	x	-	x	x
Brown coal	-	x	-	-
Peat/residue	-	x	-	x
Sulfur	-	x	-	x
Gypsum	-	x	x	x
Phosphate rock	x	-	x	x
Limestone	x	-	x	x
Rice hulls	-	x	-	-
Grains	-	x	-	-
Ores - hard	x	-	-	-
Ores - soft	x	-	x	x

sylvanite cement plant and 1919 when a successful boiler installation was made at Oneida Street Station in Milwaukee was a testing time for this type of equipment. Early during this period the C-E Raymond Roller Mill was developed to pulverize coal for storage systems serving metallurgical furnaces and cement kilns, and by 1919 several hundred of these mills were being operated successfully. A catalog published in 1900 stated, "The Raymond Roller Mill crushes and grinds the material by gravity and centrifugal force," and described it as a slow speed machine with great capacity and one that requires less power per ton of a product than any other mill. A listing of projects for which the Raymond Roller Mill, Fig. 16-11, was supplied reads like a history of pulverized coal applications, including

cement kilns, railroad and coal mine stationary plants, malleable iron furnaces, copper reverberatory furnaces and open hearths. Hence when pulverized coal gained a foothold in the central station industry after World War I this machine was a fully developed and standardized pulverizer which was specified for many of the pioneering installations.

The early mills were built for a maximum capacity of six tons per hour of 55 grindability coal when grinding to a fineness of 65 per cent minus 200 mesh. By 1930 the maximum capability of this mill design had been increased to 15 and then to 25 tons per hour. Practically all of these mills used external dryers to predry the coal before use in the pulverizer. The economic disadvantages of these dryers helped to bring about internal

## Interface Correspondence



To: Mr. C. R. Lewandowski  
w/att.

Florida Power Corp.  
Crystal River #2  
Contract No. 17965

V. Llinares  
Performance Design  
Power Systems Services

cc: B. H. Smith  
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File

Coal Conversion  
Coal - Petro Coke Firing

September 28, 1976

Reference: Mr. A. J. Ormston's September 3, 1976 letter to Mr. J. C. Sullivan.

According to Mr. Ormston's letter when Crystal River #2 is converted to coal (by the end of 1976), it will initially burn Hoke Kentucky #6 and Amax Gibraltar simultaneously using separate bunkers, feeders, and fuel nozzle levels. The customer is interested in firing (delayed) petroleum coke as a supplemental fuel which would be mixed with either coal on a 50:50 energy wise basis during the barge loading phase at New Orleans. At this time, he reports a Amax coal - petro coke blend seems the most likely.

Based on the above, we envision several combinations of coal and petro coke and firing levels being used. For example, since the unit has five firing levels (5 mills), three of the levels could fire, say Hoke #6, and the remaining two Amax plus petro-coke. On the other hand, three levels of Hoke #6 and petro-coke and two of Amax are possible. Nevertheless, our analysis indicates that the amount of petro-coke burned could vary from 20 to 30% of the total MCR heat input.

We also noted that the contemplated petro-coke tonnage is 200,000 tons per year which when compared to the total energy consumption at MCR for the same period would provide around 14% of the energy required. Therefore, to reconcile the difference between the 25% (average) intimated above and the 14% value, we assume the plant capacity factor will either be 58% or the entire 200,000 tons of supplemental fuel would be consumed in six (6) months or so.

-3-

September 28, 1976

2. (Continued)

Furnace slagging, if anything, tended to be slightly lessened with petro-coke/coal firing. No difference was discerned in main steam temperatures, high and low temperature corrosion, airheater exit gas temperatures, and carbon loss in the ash. A similar situation was indicated by the data at Yorktown in this range.

3. Should the customer decide on pre-bunker blending i.e., barge blending, we see no major change in slagging properties between (1) firing Hoke #6 and Amax simultaneously and (2) firing both coals simultaneously one of which is blended on a 50:50 basis with petro-coke. For the record, the Hoke/petro-coke combination might be slightly better from the slagging viewpoint.\*

However, depending on which coal-petro coke is used and the number of firing levels involved (3 of 5 or 2 of 5), there are significant differences in the total pounds of ash generated per million BTU fired. Our calculations indicate that firing Amax coal and petro-coke, whether in two or three mills, tends to yield lower ash rates (4.5 to 4.7#ash per 10<sup>6</sup>BTU) as compared to Hoke #6 and petro-coke (5.5 to 7#ash per 10<sup>6</sup>BTU). This is not unexpected since the Amax has 2.5 times more ash than the Hoke and anything that will reduce the amount of Amax will in turn lower the ash loading.

It is interesting to note that if segregated milling firing is used - i.e., 2 levels of Amax, 2 levels of Hoke and 1 level of petro-coke, the ash production would be on the order of 5.7#ash/10<sup>6</sup>BTU. Note that all of the above quantities for pre-bunker blending are based on 50:50 energy blend basis which is somewhat different than a 50:50 weight blend due to the differences in HHV's between the coals and petro-coke.

4. Attached is a copy of a paper published in the Mechanical Engineering Magazine, January, 1959 issue by Mr. S. C. Brown, Jr. of VEPCO entitled "Utility Boiler Fired with Delayed Coke and Coal". The paper related VEPCO's experience at Yorktown and includes curves of performance which should be of interest to Florida Power Corp.

*V. Llinares*  
V. Llinares

VL:1kr

Attachment

- \* - The above comments on slagging were based on assumed petro-coke ash analysis. If the customer plans to burn petro-coke and coal, we would like to confirm these judgements by obtaining samples of petro-coke and both coals and measuring the influence of firing varying percentages by laboratory testing.

**facsimile**  
**TRANSMITTAL**

**to:** Al Linero and Clair Fancy  
**fax #:** 904 922-6979  
**re:**  
**date:** March 3, 1997  
**pages:** 12, including this cover sheet.

**PLEASE DELIEVER TO AL LINERO AND CLAIR FANCY ASAP.**

From the desk of...

**Mr. Brian Beals**  
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