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Drying and Preheating Coals Before Coking

Part 2. Coal Blends

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ABSTRACT

The coal preheater, designed and built by the Illinois State Geological Survey, has been utilized to determine the effects of drying and preheating coal blends, which are, or might be, used for commercial production of blast furnace coke in the Midwest area. Coal blends dried and preheated to a maximum of about 450° F are charged into the pilot coke oven and the resultant cokes are tested. Results of tests on four blends are reported.

Tests indicate, as previously found with individual coals in Part I of this study, that preheating causes a consistent increase in coking rate. Coke-oven capacity may be increased from 25 to 50 percent. Coke strength, measured by the ASTM tumbler test, is not affected significantly by preheating coal blends, provided a strong coke can be made without preheat. Other physical properties of coke are not greatly affected. However, the pressure exerted on coke-oven walls is increased.

INTRODUCTION

Although there has been no commercial break-through in the design of equipment for preheating and charging hot coal to coke ovens, it has been suggested that after replacing certain older coke-oven batteries with tall ovens, the next expansion of coke production might logically be accomplished by coal preheating.

No attempt will be made in this publication to cite the literature pertaining to this subject, except to mention two reports given in 1956 and 1959. The first, (Smith et al., 1956) was presented by the U. S. Bureau of Mines, and the second (Perch and Russell, 1959) by Koppers Company. Both reports describe preheating

tests made with Illinois coals (among others) in small-scale coke ovens. The Koppers report also describes former tests made in ovens of commercial size.

The first coals to be preheated and studied in the Illinois State Geological Survey' s experimental program were individual coals dried and preheated over a wide temperature range before coking. Results, published in Circular 423 (Jackman and Helfinstine, 1968) as Part I of this multi-phase study, indicated that preheating consistently reduced the time required for coking, thereby increasing the production capacity of coke ovens.

Following this initial study, other series of coking tests have been made on coal blends normally used for production of metallurgical coke. These blends were first dried and preheated in the coal preheater built in the Geological Survey laboratories, charged hot into the pilot coke oven, and coked at normal flue temperature. Complete coking results obtained on four such coal blends are described in this publication.

Other aspects of preheating, such as the possibility of reducing the percentage of low-volatile coal in a blend without reducing coke strength or otherwise affecting coke physical properties adversely, are being studied and will be discussed in a future publication.

It is suggested also that a milder preheating procedure might be developed that would be designed only to reduce or eliminate coal moisture before charging to coke ovens. Such a process might precede the development of the more difficult, higher temperature preheating procedure. Removal of surface moisture and a portion or all of the inherent moisture should result in higher and more uniform bulk density without addition of oil, as well as in reduced under-firing and faster coking.

A recent article by Yoshida (1967) reviews the testing programs at three Japanese coke plants. Our translation of this article indicates that coals were partially heat dried from an average of about 8.0 percent moisture to from 3.6 to 5.6 percent moisture before charging to commercial coke ovens. Coking time was shortened 2 to 10 percent, and coke productivity was increased 6 to 16 percent. The coke became stronger, and there was a saving in heat for under-firing. Similar coking tests on American coal blends will be studied in our laboratories as time permits.

Equipment and Procedures

The coal preheater, which was designed and built by the Illinois State Geological Survey, has been described in Part I of this study (Jackman and Helfinstine, 1968). Briefly, it consists of a rotating steel drum, 36 inches in diameter, holding 700 pounds of coal when half filled, or enough for one coal charge to the pilot coke oven. This drum rests on rollers within an insulated furnace and may be rotated at a rate of one-half revolution per minute. Lifting fins cause the coal to mix continuously as the drum is rotated. The furnace is heated electrically to a temperature of 500° F. Time required for heating and equalizing coal temperatures in the drum varies from $3\frac{1}{2}$ to 7 hours and depends on the moisture content of the coal and the temperature to which it is preheated.

After the coal is dried or preheated, the drum is lifted out of the heating furnace and upended over the pilot coke oven (Jackman, Helfinstine, Eissler, and Reed, 1955). Coal is dropped through the charge hole into the 17-inch width oven and coked

normally at an oven flue temperature of 2300° F. Coking is assumed to be completed when coke temperature at the center of the oven reaches 1775° F. Coke is then pushed from the oven, quenched, and tested by the usual procedures.

Acknowledgments

We wish to acknowledge the assistance and cooperation of the coke producers in the Chicago and St. Louis areas and the coal producers of Illinois, who by their continuing interest and their contributions of coals and equipment have aided this investigation.

TESTING PROGRAM

Four coal blends were studied in this series of tests. Three of the blends contained Illinois coals in amounts ranging from 30 to 80 percent. The fourth blend contained all eastern coals. Analyses of these blends are shown in table 1.

A minimum of six coking tests were made on each blend studied. These tests included one on the moist coals as received, one on the air-dried coals after evap-

TABLE 1 — ANALYSES OF COAL BLENDS TESTED[1]

Coal blend	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)	Sulfur (%)	Free swelling index	Maximum Gieseler fluidity (dial div per min)
Blend A							
60% Illinois No. 6 20% Illinois No. 5 20% Pocahontas	7.5	33.0	59.7	7.3	1.02	5	9
Blend B							
40% Illinois No. 6 40% Sewell 20% Pocahontas	6.0	30.1	64.0	5.9	0.83	6½	40
Blend C							
45% Eastern Kentucky high volatile 30% Illinois No. 6 25% Pocahontas	4.3	32.9	60.9	6.2	1.11	6	268
Blend D							
75% Eastern Kentucky high volatile 25% Pocahontas	4.5	32.5	61.0	6.5	1.29	7	890

[1]All analyses made by the Analytical Section of the Illinois State Geological Survey.

oration of surface moisture, one on the coals after heat drying for approximately two hours at 210° F, and the remaining on the coals preheated to temperatures ranging from 230° to 495° F.

Detailed results of these coking tests are shown in the tables that form the Appendix of this publication. Reported results include coking time, bulk density of coal in the coke oven, coke physical properties and yields, coal moisture as charged to the coke oven, maximum wall pressure during carbonization, and increases in coke-oven capacity as drying and preheating temperatures are raised.

Certain operating data have been plotted and curves drawn to better illustrate the effects of coal drying and preheating. In these graphs, the "as received" and "air-dried" data are plotted at the left against moisture content of the coals as charged to the coke oven. Data from the "heat-dried" coals are plotted against both moisture content and the drying temperature. When preheated to temperatures that are higher than normally obtained when drying, the sensible heat of the coal is the most important factor. Therefore, data obtained from the "preheat" tests are plotted against preheat temperature.

Moisture contents of heat-dried and preheated coals were obtained by subtracting the percentage weight loss in the preheater from the moisture content determined on each of the coals before preheating. At the higher preheat temperatures this loss sometimes exceeded the original coal moisture by as much as one percent, or slightly more. In these cases, the coal moisture given in the tables is shown as a negative amount, and it is assumed that some small amount of volatile matter has been evolved.

As explained in Circular 423, describing tests on single coals, certain data points deviate from the expected values. Fortunately, only a few such results were obtained in these tests. Where these did occur, the data have been plotted as determined, but the curves have been drawn to show the most probable trends.

RESULTS OF TESTS

Blend A

Blend A, which has been coked in the Midwest area for many years, consists of 60 percent Illinois No. 6, 20 percent Illinois No. 5, and 20 percent low-volatile Pocahontas Coals. The high percentage of Illinois coals in Blend A, along with the high moisture content of 7.5 percent, made it probable that preheating would cause a major decrease in coking time and a maximum increase in potential coke capacity. Experimental results have proved these assumptions to be true.

After pulverization to approximately 85 percent minus 1/8-inch size, Blend A was first coked in the "as received" condition at 2300° F flue temperature under essentially commercial operating conditions. Coking was completed in 16 hours and 45 minutes.

Air drying this coal to remove surface moisture caused the total moisture content to drop from 7.5 to 6.9 percent and the dry-coal bulk density to increase from 46.7 to 47.5 pounds per cubic foot. Coking time was increased by 10 minutes. Physical properties of the cokes from both the "as received" and "air-dried" coals were similar, and there was no signigicant change in pressure on oven walls.

Heat drying this coal at 210° F caused less than one-half percent additional reduction in coal moisture, and the coking time remained unchanged at 16 hours and 55 minutes. The bulk density reported for the heat-dried coal was very unrealistic and obviously in error. Coke physical properties and yields, and also wall pressure, were similar to those obtained in the previous two tests.

Following these initial drying studies, coal Blend A was preheated to temperatures of 260°, 350°, and 430° F. In each case, the preheated coal was coked under the same oven temperature conditions. Coking time was reduced to a minimum of 11 hours and 40 minutes, which represents a reduction of 5 hours and 5 minutes, as compared with the time required to coke the "as received" coal.

Coke and tar yields, computed on the dry-coal basis, remained very uniform throughout the entire series of tests, indicating that very little, if any, weathering had taken place during preheating. Dry-coal bulk density of the preheated coals remained practically constant, only slightly above that of the "air-dried" coal. From these data it has been computed that an oven battery operated on this blend of coals preheated to 430° F could produce 48 percent more furnace-size coke than when operated on "as received" coal.

Pressure exerted on coke oven walls was found to increase consistently at higher preheat temperatures and to reach a maximum of 2.2 pounds per square inch when the coal was preheated to 430° F. Complete coking results of this series of tests are shown in figures 1 and 2 and in table A of the Appendix.

Blend B

Blend B, with certain variations, has been used over an extended period to produce a satisfactory blast-furnace coke. This blend contains 40 percent Illinois No. 6, 40 percent Sewell, and 20 percent Pocahontas Coals. Although containing only half as much high-moisture coal as Blend A, it nevertheless responds well to preheating and showed a possible increased coke production of nearly 33 percent when preheated to 495° F. Interpolated back to 450° preheat, this increase would amount to approximately 30 percent.

Blend B "as received" and prepared for carbonization contained 6.1 percent moisture. Air drying reduced this moisture to 4.8 percent and heat drying at 212° F reduced moisture still farther to 4.1 percent. The dry-coal bulk density of this blend was increased by air drying from 46.2 to 48.5 pounds per cubic foot and by heat drying to 47.8 pounds. Bulk density remained fairly constant at about this level as the coal was preheated to as high as 495° F.

The time required to coke this blend "as received" was 16 hours and 20 minutes. It required 17 hours and 40 minutes to coke the air-dried coal, presumably because of the increase of 2.3 pounds in bulk density. The heat-dried coal required exactly 16 hours at a bulk density midway between the other two tests, but with the moisture reduced to 4.1 percent.

Following these drying tests, this blend of coals was preheated to 290°, 418°, and 495° F. All coals were coked at the standard flue temperature, and coking time was reduced to 12 hours and 30 minutes at the highest preheat. Details of the results of all coking tests are shown in figures 3 and 4, and in table B of the Appendix. Coke strength remains quite constant, with the tumbler stability ranging from 58.6 to 62.3. Other physical properties such as coke sizing and apparent gravity do not vary greatly. Coke and tar yields also remain very constant.

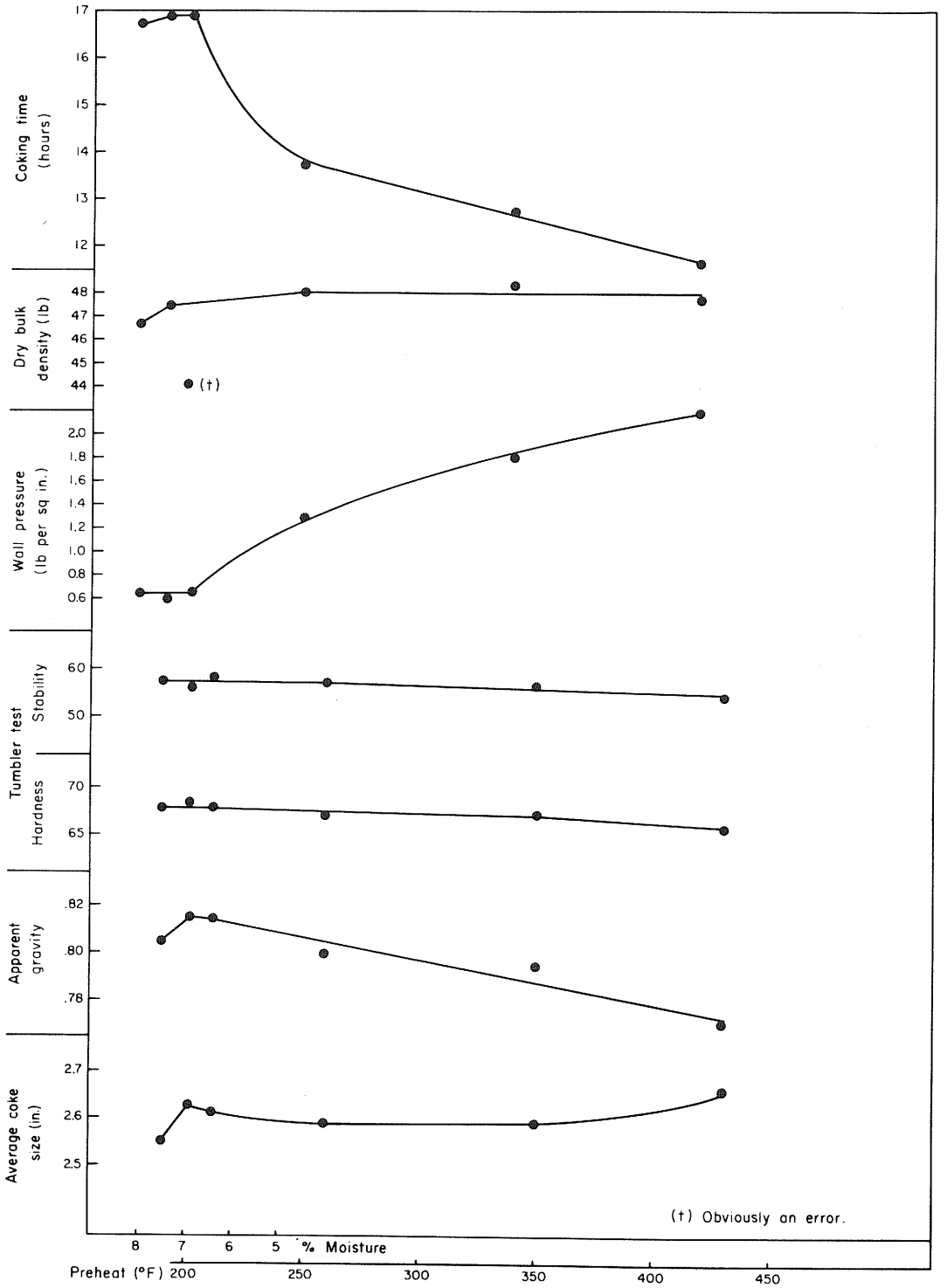

Figure 1 - Results of coking tests on Blend A.

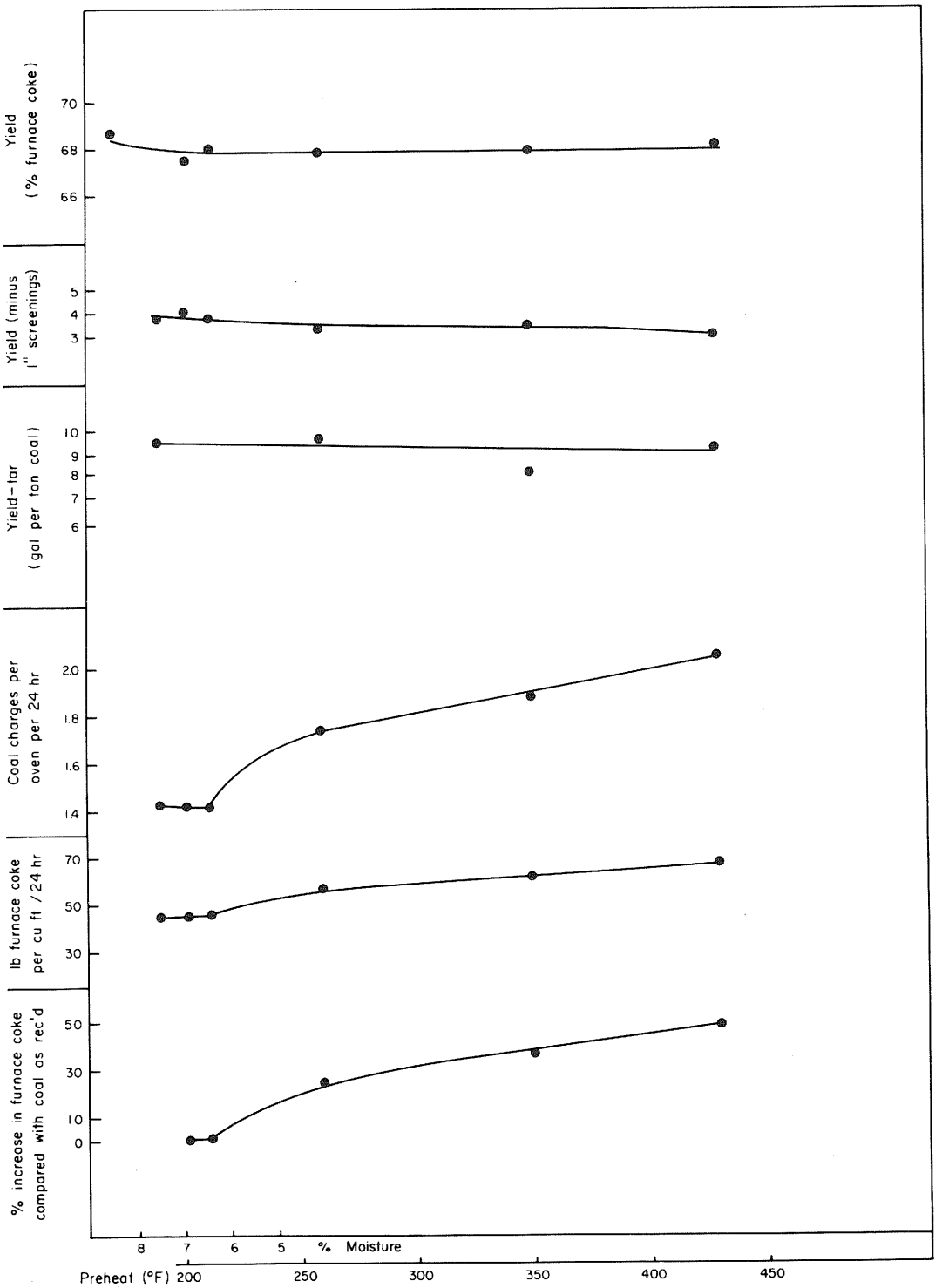

Figure 2 - Results of coking tests on Blend A.

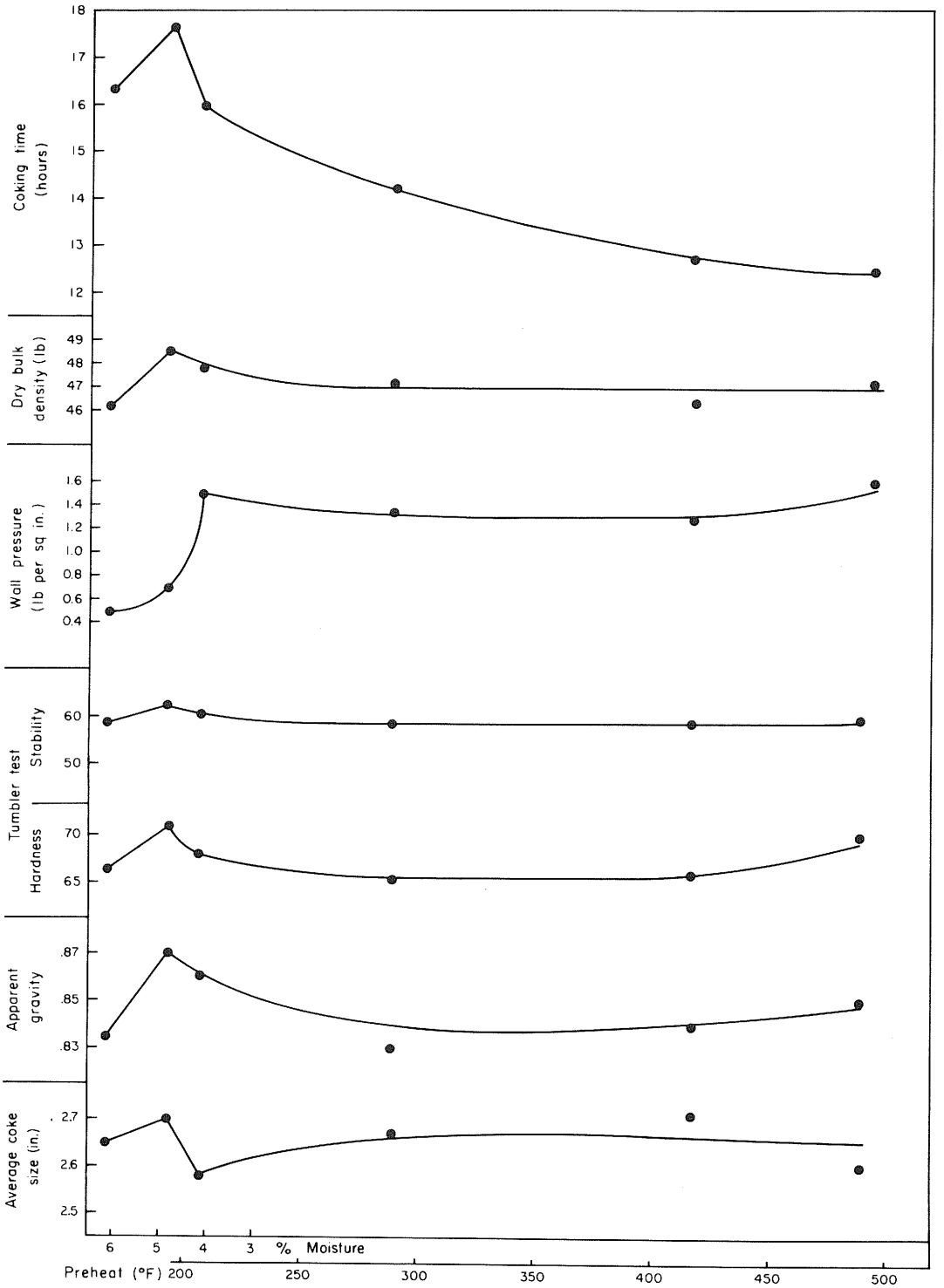

Figure 3 - Results of coking tests on Blend B.

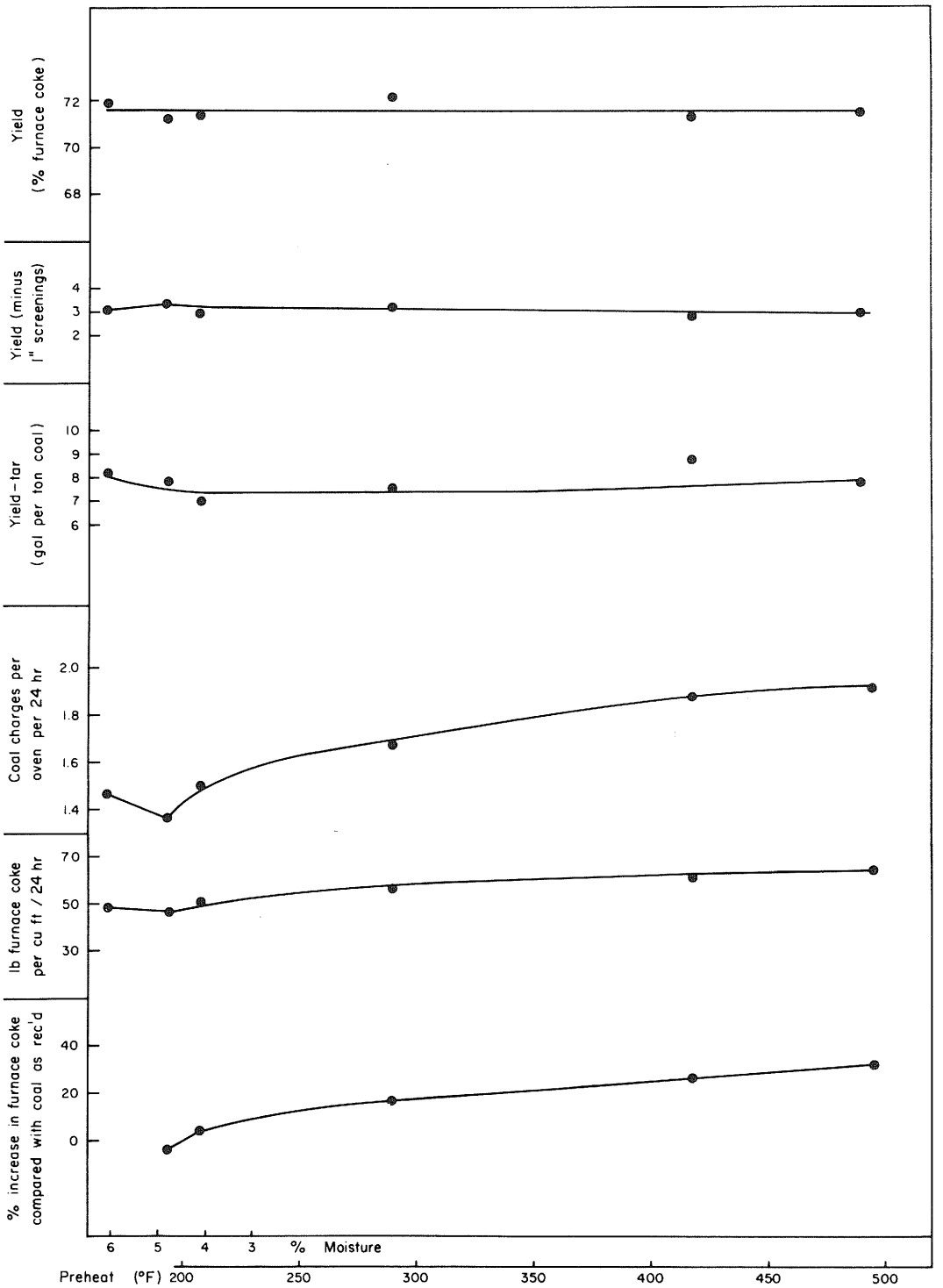

Figure 4 - Results of coking tests on Blend B.

In contrast to Blend A, the wall pressure obtained when coking this blend of preheated coals rose from 0.5 to about 1.5 pounds per square inch and remained fairly constant as preheat was increased, never exceeding 1.6 pounds per square inch.

Blend C

Blend C contained 45 percent eastern Kentucky high-volatile, 30 percent Illinois No. 6, and 25 percent Pocahontas Coals. Moisture content of the blend as prepared from the "as received" coals was 5.0 percent. This moisture was reduced to 4.5 percent by air drying and to 3.15 percent when heat dried at 210° F. Further preheating removed all moisture, as with the other blends tested, and the coking time was reduced from 16 hours and 40 minutes to 13 hours and 25 minutes when preheating to 450° F. The computed increase in coke production was 25.2 percent.

The bulk density of this coal was 47.2 pounds per cubic foot as received. This increased to 49.3 pounds when air dried and maintained a fairly constant value between 48 and 49 pounds as the coal was preheated. Coke strength, as indicated by the tumbler stability, remained constant at about 55 throughout the entire series of tests. Coke sizing and apparent gravity, and the yields of tar and furnace-size coke, likewise remained constant throughout. Pressure exerted on coke-oven walls registered 1.5 pounds per square inch when the coal was heat dried and did not exceed 1.3 pounds per square inch at any of the subsequent preheat temperatures. Details of all tests are shown in figures 5 and 6 and in table C of the Appendix.

Blend D

Blend D contained all eastern coals including 75 percent eastern Kentucky high-volatile and 25 percent Pocahontas. Moisture content of this blend "as received" was 3.7 percent, which was reduced by air drying and heat drying to 2.9 and 2.2 percent, respectively. Coking time of the "as received" blend was 15 hours and 50 minutes, which was reduced to 12 hours and 25 minutes when the blend was preheated to 450° F. The "as received" bulk density of 45.5 pounds was increased to 48.8 pounds by air drying, and to 46.0 pounds by heat drying at 215° F. Bulk density remained at 46.0 pounds, except at 450° preheat where it increased again to 48.3 pounds.

Tumbler stability of the coke made from Blend D ranged from 50 to 53.7 throughout the entire series of tests, except for a decrease to 46 when the blend was preheated to 450° F. Coke sizing became slightly smaller at the higher preheat temperatures, but the percentage of coke screenings (minus $\frac{1}{2}$-inch) remained practically constant throughout. Furnace-size coke yields did not vary appreciably.

These tests indicate that by preheating this blend of eastern coals to 350° F, approximately 16 percent additional furnace coke could be produced, and by increasing the preheat temperature to 450° F approximately 32 percent additional coke could be made. Details of all tests are shown in figures 7 and 8 and in table D of the Appendix.

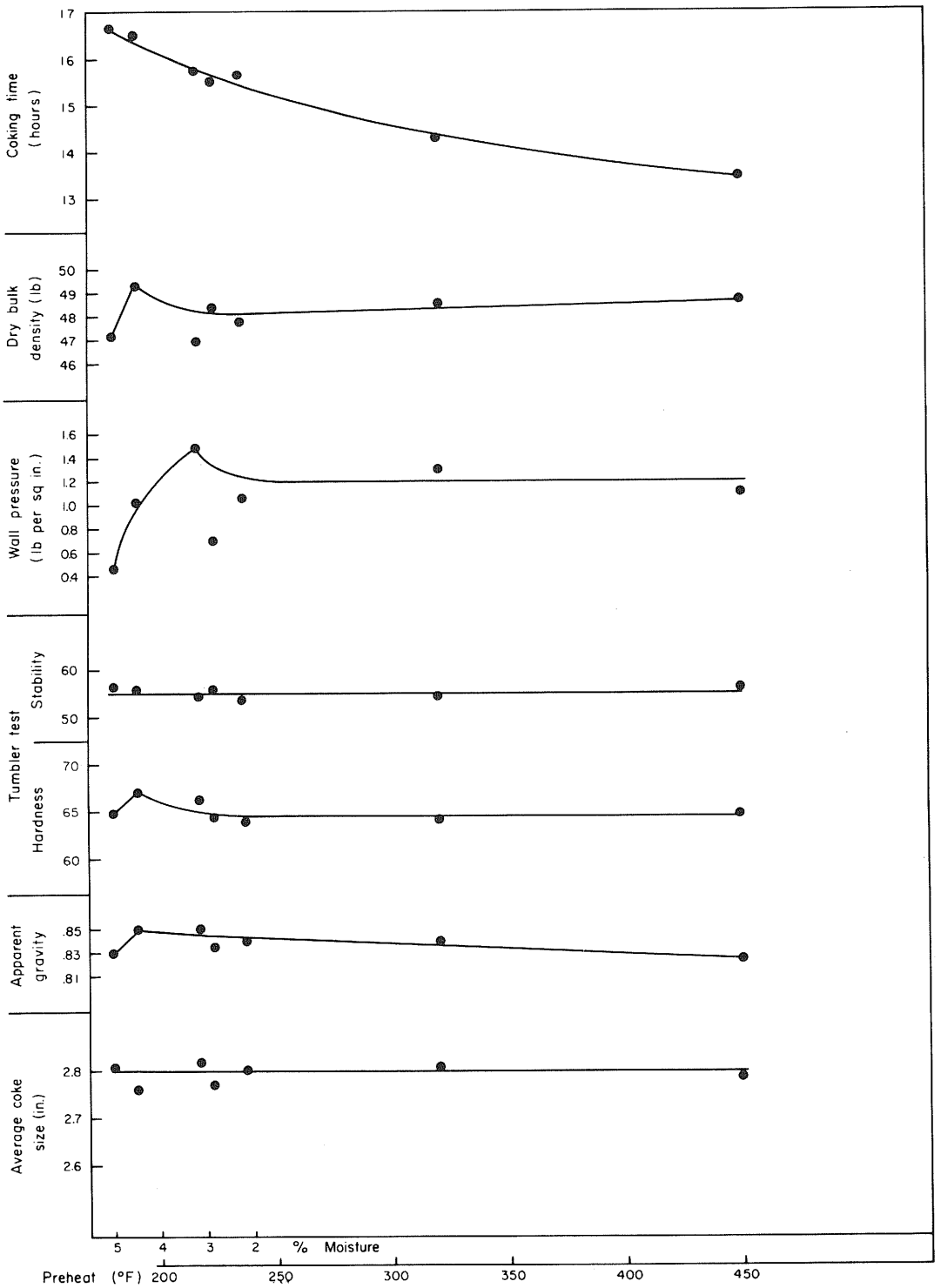

Figure 5 - Results of coking tests on Blend C.

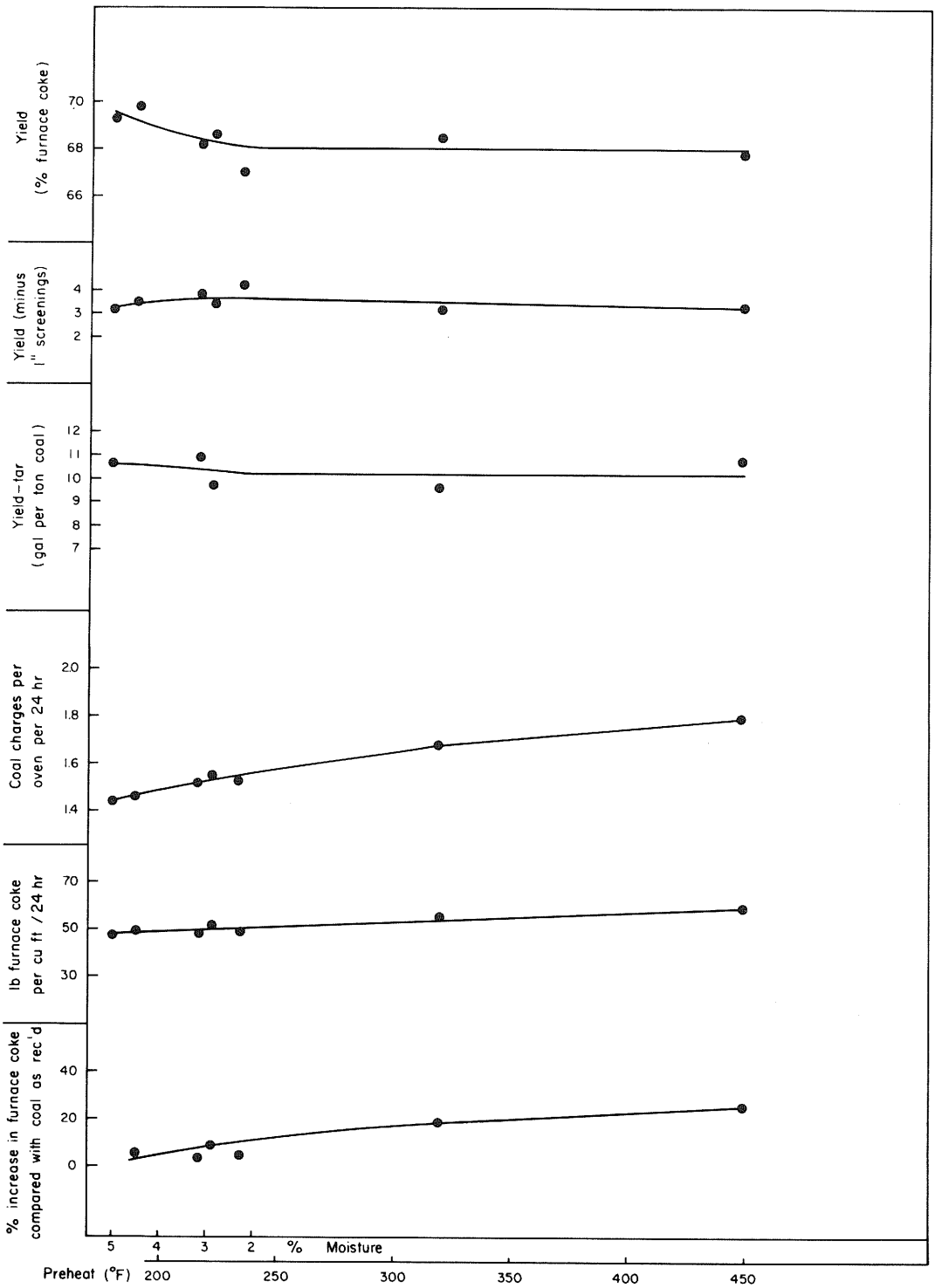

Figure 6 - Results of coking tests on Blend C.

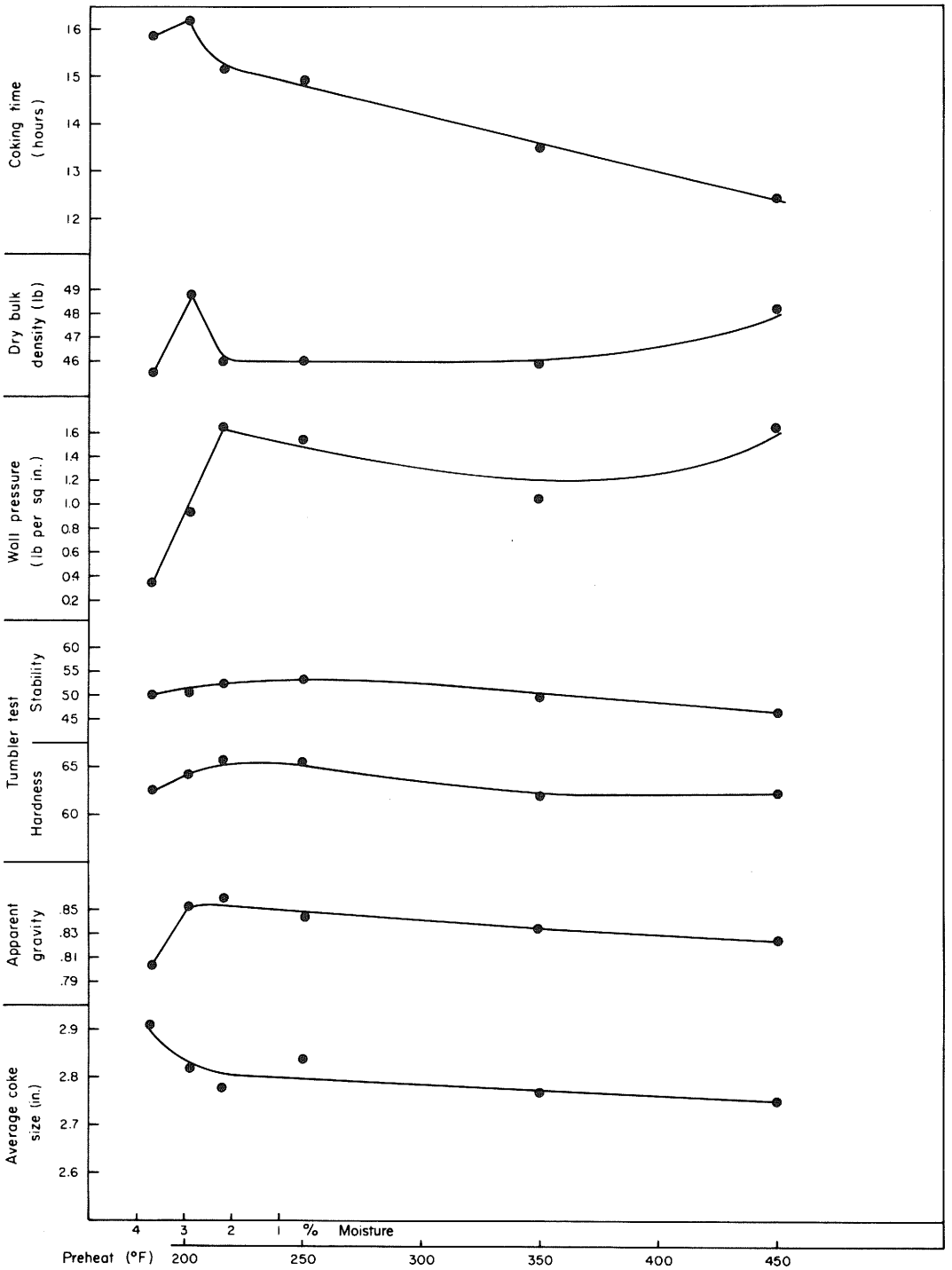

Figure 7 - Results of coking tests on Blend D.

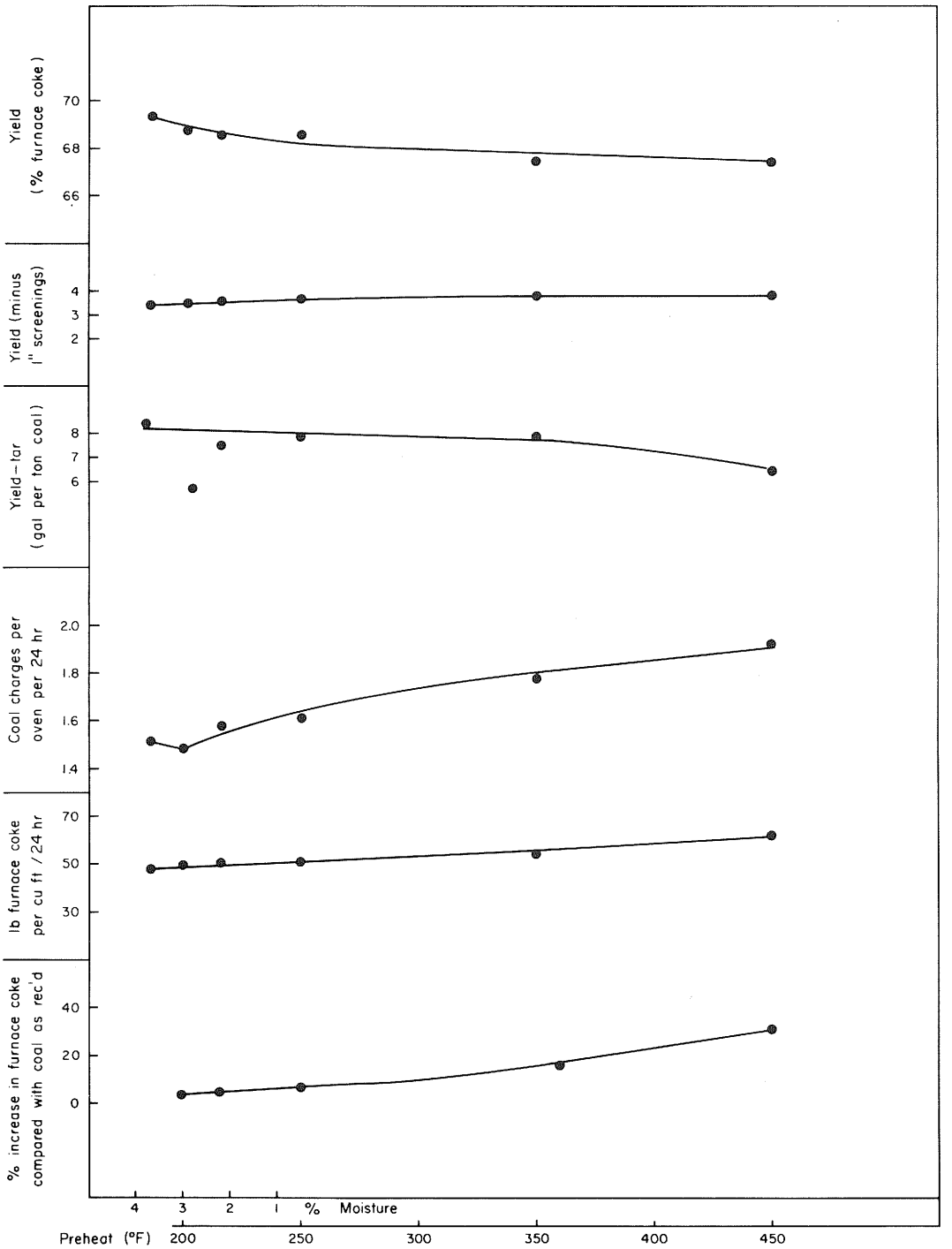

Figure 8 - Results of coking tests on Blend D.

SUMMARY AND CONCLUSIONS

Following coking tests on preheated individual coals, described in our Circular 423, similar studies have been made on four coal blends, all of which were dried and preheated over a range of 230° to 450° F before coking.

It has been shown that preheating consistently reduces the coking time, thereby increasing the potential coking capacity of a coke-oven battery. This increase in capacity for the blends studied ranged from approximately 25 to 50 percent at the highest preheat temperatures tried.

It also has been shown that coke strength is not affected appreciably by preheating blends that are capable of producing strong coke without preheat. Coke sizing is not greatly affected, nor are coke or tar yields.

Expansion pressure on coke oven walls is increased by preheating. Wall pressure remained within the commonly accepted safe limit of 1.5 pounds per square inch with one of the blends studied. Two blends produced a maximum wall pressure of 1.6 pounds per square inch, and the other attained a maximum of 2.2 pounds with 430° F coal preheat temperature. It appears from these and other tests that rapid coking of preheated coals may cause the plastic coal envelope that is formed inside the coke oven to be nonuniform in structure. This may rupture at some weak point, with low indicated wall pressure, or may remain intact until a higher pressure is reached and recorded.

The tendency for these preheated blends to increase wall pressure, and also to give variable test results, makes it desirable to study pressure characteristics carefully before preheating any blend of coal for coking in commercial ovens.

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APPENDIX

Tables A through D of this section present the complete pilot plant coking results for each of the coal blends studied and described in this publication. Data include preheat temperatures, coking time, dry coal bulk densities, coke physical properties, yields of coke and tar, coal pulverization, moisture in dried and preheated coals, and effect of preheating on the capacity of coke ovens to produce coke.

Table E shows the laboratory analyses of the cokes produced in each series of drying and preheating tests. All analyses are made by the Analytical Section of the Illinois State Geological Survey.

TABLE A — RESULTS OF COKING TESTS ON BLEND A

Blend A 60% Illinois No. 6 20% Illinois No. 5 20% Pocahontas	Condition of coal					
	As rec'd.	Air dried	Heat dried at 210° F	Preheat at 260° F	Preheat at 350° F	Preheat at 430° F
	Run number					
	1058 E	1159 E	1160 E	1056 E	1059 E	1042 E
Coking time (hr:min)	16:45	16:55	16:55	13:45	12:45	11:40
Bulk density (dry coal; lb per cu ft)	46.7	47.5	44.1†	48.1	48.4	47.8
Coke physical properties						
Tumbler test						
Stability	57.7	56.2	58.4	57.0	56.9	54.3
Hardness	67.8	68.5	68.0	67.2	67.2	65.7
Shatter test (%)						
+2"	75.4	69.0	73.0	75.8	80.0	77.4
+1½"	90.2	90.0	91.0	91.0	93.0	90.8
+1"	95.2	96.0	96.0	96.2	96.8	95.8
Sizing (%)						
+4"	5.2	6.6	6.2	5.0	7.2	12.0
4" x 3"	26.2	29.5	28.1	28.3	25.4	22.2
3" x 2"	43.1	40.9	42.4	42.3	41.4	40.2
2" x 1"	20.1	17.1	17.8	19.6	21.0	21.2
1" x ½"	1.4	1.7	1.9	2.0	2.1	1.9
−½"	3.7	4.2	3.6	2.8	2.9	2.5
Average size (in.)	2.55	2.63	2.61	2.59	2.59	2.66
Apparent gravity	0.805	0.815	0.815	0.80	0.79	0.77
Coke yields (% of dry coal)						
Total coke (dry)	72.5	71.6	71.8	71.2	71.4	71.3
Furnace (+1") (dry)	68.7	67.5	68.0	67.8	67.9	68.2
Nut (1" x ½") (dry)	1.1	1.2	1.3	1.4	1.5	1.4
Breeze (−½") (dry)	2.7	2.9	2.5	2.0	2.0	1.7
Tar yield (gal dry tar; per ton dry coal)	9.6	—	—	9.7	8.2	9.3
Oven wall pressure (lb per sq in.)	0.65	0.60	0.65	1.3	1.8	2.2
Pulverization (−1/8")	—	86.2	84.0	82.6	—	—
Coke temperature (° F)	1775	1775	1775	1775	1775	1775
% moisture in coal as charged*	7.5	6.9	6.4	1.1	0.0	−1.2
Coke oven capacity						
Coal charges/oven/24 hr	1.43	1.42	1.42	1.74	1.88	2.06
Lb furnace coke/cu ft/24 hr	45.3	45.5	46.0	56.7	61.8	67.1
% increase in furnace coke (compared with coal "as received")	—	0.4	1.5	25.2	36.4	48.1

*Minus values indicate weight loss on preheating greater than ASTM moisture values.
†Obviously an error.

TABLE B — RESULTS OF COKING TESTS ON BLEND B

Blend B 40% Illinois No. 6 40% Sewell 20% Pocahontas	Condition of coal					
	As rec'd.	Air dried	Heat dried at 212° F	Preheat at 290° F	Preheat at 418° F	Preheat at 495° F
	Run number					
	1106 E	1135 E	1108 E	1109 E	1110 E	1139 E
Coking time (hr:min)	16:20	17:40	16:00	14:15	12:45	12:30
Bulk density (dry coal; lb per cu ft)	46.2	48.5	47.8	47.2	46.4	47.2
Coke physical properties						
Tumbler test						
Stability	58.7	62.3	60.3	58.7	58.6	59.3
Hardness	66.4	70.9	68.0	65.3	65.9	69.8
Shatter test (%)						
+2"	81.4	73.0	72.0	69.0	70.2	67.0
+1½"	93.0	93.0	94.0	92.0	91.8	91.2
+1"	97.0	97.0	97.0	96.8	97.0	97.0
Sizing (%)						
+4"	6.0	8.7	5.7	7.4	10.2	7.7
4" x 3"	28.4	29.0	24.7	28.3	27.7	25.7
3" x 2"	44.5	40.9	45.7	41.8	39.7	39.9
2" x 1"	17.0	16.9	20.0	18.3	18.5	22.7
1" x ½"	1.2	1.4	1.4	1.3	1.2	1.5
–½"	2.9	3.1	2.5	2.9	2.7	2.5
Average size (in.)	2.65	2.70	2.58	2.66	2.71	2.60
Apparent gravity	0.835	0.87	0.86	0.83	0.84	0.85
Coke yields (% of dry coal)						
Total coke (dry)	75.0	74.6	74.3	75.4	74.2	74.5
Furnace (+1") (dry)	71.9	71.2	71.4	72.2	71.3	71.5
Nut (1" x ½") (dry)	1.0	1.1	1.0	1.1	0.9	1.1
Breeze (–½") (dry)	2.1	2.3	1.9	2.1	2.0	1.9
Tar yield (gal dry tar; per ton dry coal)	8.2	7.9	7.0	7.6	8.8	7.9
Oven wall pressure (lb per sq in.)	0.5	0.7	1.5	1.35	1.3	1.6
Pulverization (–1/8")	83.9	81.2	81.7	83.3	79.1	83.8
Coke temperature (° F)	1775	1775	1775	1775	1775	1775
% moisture in coal as charged*	6.1	4.8	4.1	0.8	–0.6	0.0
Coke oven capacity						
Coal charges/oven/24 hr	1.47	1.36	1.50	1.68	1.88	1.92
Lb furnace coke/cu ft/24 hr	48.8	47.0	51.2	57.2	62.2	64.8
% increase in furnace coke (compared with coal "as received")	——	-3.7	4.9	17.2	27.5	32.8

*Minus values indicate weight loss on preheating greater than ASTM moisture values.

TABLE C — RESULTS OF COKING TESTS ON BLEND C

Blend C 45% Eastern Kentucky high volatile 30% Illinois No. 6 25% Pocahontas	Condition of coal						
	As rec'd.	Air dried	Heat dried at 210° F	Preheat at 223° F	Preheat at 235° F	Preheat at 320° F	Preheat at 450° F
	Run number						
	1068 E	1180 E	1179 E	1067 E	1181 E	1066 E	1065 E
Coking time (hr:min)	16:40	16:30	15:45	15:30	15:40	14:18	13:25
Bulk density (dry coal; lb per cu ft)	47.2	49.3	46.9	48.4	47.8	48.5	48.6
Coke physical properties							
Tumbler test							
Stability	56.5	55.9	54.6	55.7	53.6	54.5	56.2
Hardness	64.8	67.1	66.2	64.5	63.9	64.2	64.8
Shatter test (%)							
+2"	81.2	73.2	77.2	78.4	77.0	78.0	78.0
+1½"	92.6	90.8	93.0	91.0	90.0	92.2	93.0
+1"	96.4	96.8	96.0	96.4	95.0	96.8	96.8
Sizing (%)							
+4"	12.6	9.1	11.7	14.4	9.2	17.2	14.7
4" x 3"	31.0	32.7	34.8	25.4	36.4	24.5	26.8
3" x 2"	36.2	38.2	33.9	37.7	35.6	35.3	36.1
2" x 1"	15.8	15.2	14.2	17.8	12.8	18.6	17.9
1" x ½"	1.6	1.7	2.2	1.6	2.6	1.8	1.9
-½"	2.8	3.1	3.2	3.1	3.4	2.6	2.6
Average size (in.)	2.81	2.76	2.82	2.77	2.80	2.81	2.79
Apparent gravity	0.83	0.85	0.85	0.835	0.84	0.84	0.825
Coke yields (% of dry coal)							
Total coke (dry)	72.5	73.3	72.0	72.8	71.2	71.7	71.1
Furnace (+1") (dry)	69.3	69.8	68.2	69.2	67.0	68.5	67.8
Nut (1" x ½") (dry)	1.1	1.3	1.6	1.2	1.9	1.3	1.4
Breeze (-½") (dry)	2.1	2.2	2.2	2.4	2.3	1.9	1.9
Tar yield (gal dry tar; per ton dry coal)	10.6	—	10.9	9.7	—	9.6	10.8
Oven wall pressure (lb per sq in.)	0.45	1.1	1.5	0.7	1.05	1.3	1.1
Pulverization (-1/8")	—	85.3	83.6	84.3	—	—	—
Coke Temperature (° F)	1775	1775	1775	1775	1775	1775	1775
% moisture in coal as charged*	5.0	4.5	3.15	2.3	1.8	0.9	-0.1
Coke oven capacity							
Coal charges/ oven/24 hr	1.44	1.46	1.52	1.55	1.53	1.68	1.79
Lb furnace coke/ cu ft/24 hr	47.1	49.9	48.6	51.5	49.0	55.8	59.0
% increase in furnace coke (compared with coal "as received")	—	5.9	3.2	9.3	4.0	18.5	25.2

*Minus values indicate weight loss on preheating greater than ASTM moisture values.

TABLE D — RESULTS OF COKING TESTS ON BLEND D

Blend D 75% Eastern Kentucky high volatile 25% Pocahontas	Condition of coal					
	As rec'd.	Air dried	Heat dried at 215° F	Preheat at 250° F	Preheat at 350° F	Preheat at 450° F
	Run number					
	1193 E	1187 E	1192 E	1191 E	1189 E	1194 E
Coking time (hr:min)	15:50	16:10	15:10	14:55	13:30	12:25
Bulk density (dry coal; lb per cu ft)	45.5	48.8	46.0	46.0	46.0	48.3
Coke physical properties						
Tumbler test						
Stability	50.0	50.5	52.8	53.7	49.6	46.4
Hardness	62.5	64.3	65.7	65.5	62.1	62.1
Shatter test (%)						
+2"	76.4	75.0	68.0	74.8	76.8	66.0
+1½"	91.0	90.0	88.0	92.0	91.2	88.0
+1"	96.2	95.0	95.0	96.0	96.4	95.0
Sizing (%)						
+4"	12.0	12.3	9.8	12.0	9.9	10.1
4" x 3"	38.5	31.6	33.7	35.1	33.3	32.3
3" x 2"	33.1	37.5	36.1	32.9	35.7	35.9
2" x 1"	11.7	13.7	15.5	14.9	15.8	16.4
1" x ½"	1.7	2.0	2.2	2.1	2.4	2.2
-½"	3.0	2.9	2.7	3.0	2.9	3.1
Average size (in.)	2.91	2.82	2.78	2.84	2.77	2.75
Apparent gravity	0.805	0.855	0.86	0.845	0.835	0.825
Coke yields (% of dry coal)						
Total coke (dry)	73.8	72.1	72.2	72.3	71.3	71.2
Furnace (+1") (dry)	69.4	68.7	68.6	68.6	67.5	67.4
Nut (1" x ½") (dry)	1.2	1.4	1.7	1.5	1.7	1.5
Breeze (-½") (dry)	2.2	2.1	1.9	2.2	2.1	2.3
Tar yield (gal dry tar; per ton dry coal)	8.45	—	7.5	7.9	7.9	6.4
Oven wall pressure (lb per sq in.)	0.35	0.95	1.65	1.55	1.05	1.65
Pulverization (-1/8")	82.7	83.2	80.1	84.9	83.1	82.0
Coke temperature (° F)	1775	1775	1775	1775	1775	1775
% moisture in coal as charged	3.7	2.9	2.2	1.1	0.1	0.0
Coke oven capacity						
Coal charges/oven/24 hr	1.51	1.48	1.58	1.61	1.78	1.93
Lb furnace coke/cu ft/24 hr	47.6	49.5	49.8	50.8	55.3	62.8
% increase in furnace coke (compared with coal "as received")	—	4.0	4.6	6.3	16.1	31.9

TABLE E — ANALYSES OF COKES PRODUCED (in percent)

Coal blend coked	Volatile matter	Fixed carbon	Ash	Sulfur
Blend A 60% Illinois No. 6 20% Illinois No. 5 20% Pocahontas				
As received	1.2	88.6	10.2	0.74
Air dried	1.2	88.3	10.5	0.86
Heat dried at 210° F	1.3	88.5	10.2	0.88
Preheated to 260° F	1.3	88.1	10.6	0.77
Preheated to 350° F	1.4	88.2	10.4	0.81
Preheated to 430° F	1.3	88.0	10.7	0.81
Blend B 40% Illinois No. 6 40% Sewell 20% Pocahontas				
As received	1.1	91.1	7.8	0.68
Air dried	0.9	90.6	8.5	0.75
Heat dried at 212° F	1.0	91.4	7.6	0.63
Preheat to 290° F	1.1	91.4	7.5	0.72
Preheat to 418° F	1.1	91.1	7.8	0.63
Preheat to 495° F	1.3	90.3	8.4	0.68
Blend C 45% Eastern Kentucky high volatile 30% Illinois No. 6 25% Pocahontas				
As received	1.0	90.2	8.8	0.84
Air dried	1.1	89.9	9.0	0.88
Heat dried at 210° F	1.5	89.5	9.0	0.93
Preheat to 223° F	0.8	90.4	8.9	0.77
Preheat to 235° F	1.4	89.7	8.9	0.89
Preheat to 320° F	1.1	90.4	8.5	0.84
Preheat to 450° F	0.8	90.7	8.5	0.77
Blend D 75% Eastern Kentucky high volatile 25% Pocahontas				
As received	1.1	89.8	9.1	1.02
Air dried	1.1	89.4	9.5	0.99
Heat dried at 215° F	0.7	90.0	9.3	1.05
Preheat to 250° F	1.0	89.8	9.2	1.06
Preheat to 350° F	0.7	90.3	9.0	1.03
Preheat to 450° F	1.2	89.6	9.2	1.12

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