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H. W. Jackman
R. J. Helfinstine

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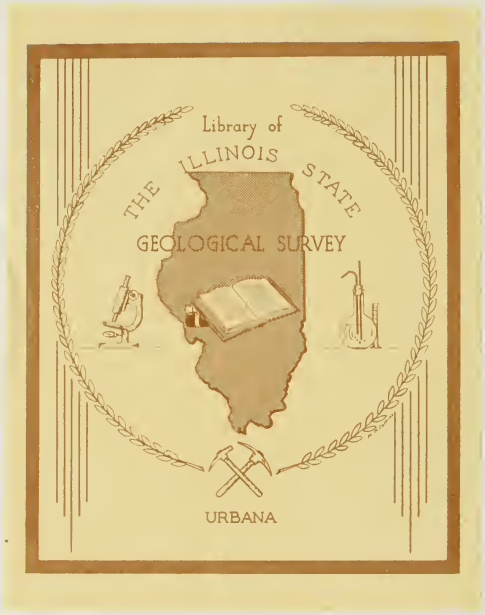
URBANA, ILLINOIS 61801
John C. Frye, *Chief*



PREHEATING COAL BLENDS AS A MEANS OF INCREASING COKE STRENGTH

H. W. Jackman and R. J. Helfinstine

ABSTRACT

Scarcity of low- and medium-volatile coals and their high delivered costs at many steel mills have made it desirable or imperative to curtail the use of such coals in the production of metallurgical coke. Yet it is desirable that coke quality should not be affected adversely and that coke-oven productivity should remain high.

Tests in the Illinois State Geological Survey pilot coke oven have shown that preheating coal blends before charging them to the oven makes it possible to reduce the percentage of these scarce coals and at the same time obtain a high production of high-quality coke.

INTRODUCTION

The scarcity and high delivered cost of low- and medium-volatile coals have made it desirable for coke producers to reduce the percentage of these coals in blends for making metallurgical coke. Tests made in the pilot coke oven at the Illinois State Geological Survey determined the minimum percentage of these lower-volatile coals that might be used in certain blends without serious detriment to coke stability.

Experimental coking studies show also that coke stability may be increased by preheating certain of these coal blends in which the amount of low-volatile constituent has been reduced materially. Cokes of metallurgical quality have been produced in this way from coal blends that otherwise would have given unsatisfactory cokes.

The coal preheater, designed and built by the Illinois State Geological Survey, has been described previously (Jackman and Helfinstine, 1968a).

Acknowledgments

We wish to acknowledge the cooperation of coke producers in the Chicago, St. Louis and southern Indiana areas and coal producers of Illinois who have furnished the coals used in the tests for this study.

TESTING PROGRAM

Three series of blends have been studied in this investigation. The first series contained Illinois No. 6 and medium-volatile coals; the second series, Eastern Kentucky, Illinois No. 6 and Pocahontas No. 3 coals; and the third series, Eagle seam coal from West Virginia, Illinois No. 5 Coal, petroleum coke and Pocahontas No. 3 coal.

In all, 15 blends have been studied, each coked in the "as received" condition, followed by other coking tests made after preheating the blends. The effects of preheat on stability, other coke properties, and yields were noted.

In the first series, the amount of medium-volatile Pocahontas coal was reduced in four steps from 30 percent to 5 percent of the total coal blend. In the second series, the low-volatile Pocahontas content was reduced in four steps from 25 to 5 percent, and in the third series the amount of petroleum coke plus Pocahontas coal was reduced in four steps from a total of 25 percent to 5 percent. (Petroleum coke is an oil refinery product that is a possible substitute for low-volatile coal, and this series of tests indicates how it might be utilized in blends of this type.)

Analyses of the coals used in blends are shown in table 1, and complete coking test results are shown in tabular form in the Appendix. In addition, coke

TABLE 1 - ANALYSES OF COALS AND PETROLEUM COKE USED IN TESTS*

Coal	Moisture (%)	Moisture free				Free swelling index	Maximum Gieseler fluidity (dial div per min)
		Volatile matter (%)	Fixed carbon (%)	Ash (%)	Sulfur (%)		
Illinois No. 6	9.6	37.7	55.4	6.9	1.10	5	20
Illinois No. 5	8.0	36.3	55.6	8.1	1.48	6	69
Med.-Vol. Pocahontas	6.1	22.8	71.8	5.4	0.49	9	1,000
Low-Vol. Pocahontas (1)	4.4	18.4	73.6	8.0	0.78	8½	67
Low-Vol. Pocahontas (2)	5.3	16.5	78.1	5.4	0.52	8	23
Eastern Kentucky	5.2	37.2	55.3	7.5	1.21	7	8,300
Eagle	3.6	34.3	60.4	5.3	0.73	8½	28,200
Petroleum Coke	0.3	15.9	84.0	0.1	1.89	-	-

*Chemical analyses by the Analytical Chemistry Section of the Illinois State Geological Survey. Volatile matter, fixed carbon, ash and sulfur on dry coal basis.

stabilities have been plotted and curves drawn (figures 1, 2 and 3) to illustrate graphically how coke strength in each series of blends has been improved by preheating.

The experimental data presented in the tables and figures of this publication are mostly the results of single coking tests, and as such, their absolute values must not be assumed to be exactly reproducible. Duplicate tests would probably show some minor variations in results. We believe, however, that the data presented are sufficiently precise to establish the trends as shown.

RESULTS OF TESTS

(A) Blends of Illinois No. 6 and Medium-Volatile Coals

The initial blend in the first series of tests contained 70 percent Illinois No. 6 and 30 percent medium-volatile coals. The coke produced had a high stability index of 56.8 and a hardness index of 66.6. Coke sizing and yields were normal, with the percentage of coke screenings (minus 1 inch) equal to 5.3 percent of the weight of the total coke produced. To determine what effect preheating might have on the coking properties, this coal blend was coked again after preheating at 450° F. No significant effects on the coking properties or on yields of the coke were noted. Dry-coal bulk density was increased appreciably however, and coking time was reduced from 17 hours to 12 hours: 30 minutes. There was an indicated gain of 46 percent in coke-oven productivity.

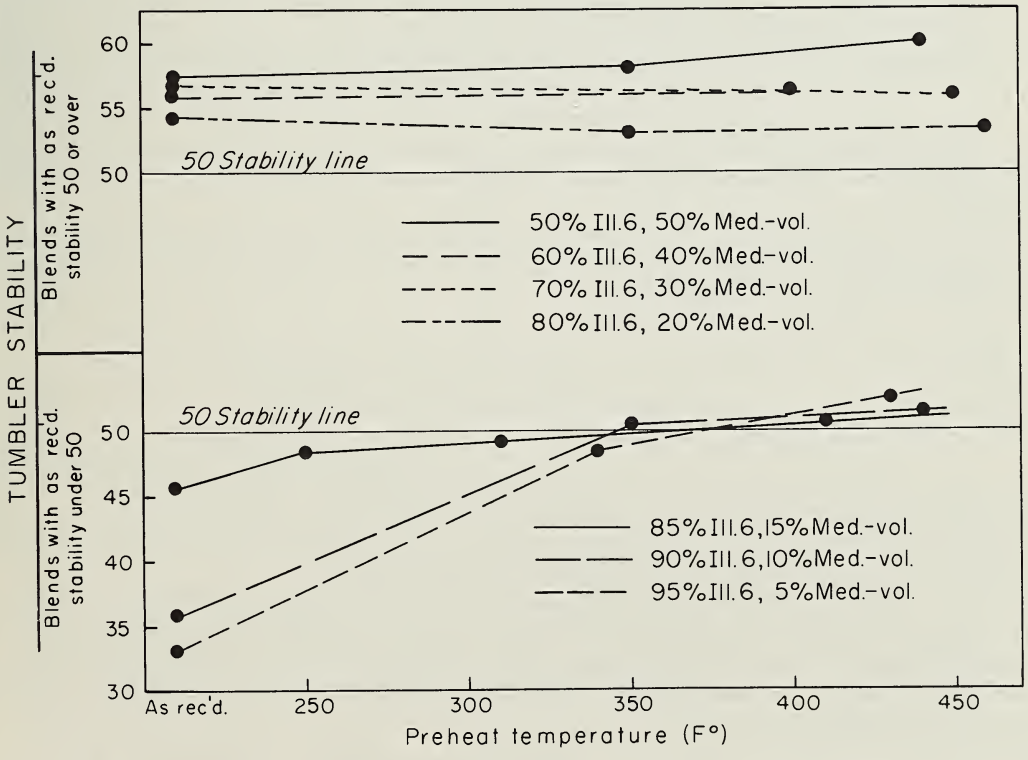


Fig. 1 - Effects of preheating blends of Illinois No. 6 and medium-volatile coals.

Reducing the content of the medium-volatile constituent of this blend to 20 percent, with a corresponding increase in Illinois No. 6 to 80 percent, had very little effect on the coke produced except for a small increase in the yield of minus 1 inch screenings. Preheating this blend to a maximum of 450° F likewise had no significant effect on coke properties.

Coking results from these two blends indicate that when the stability of coke made from a blend of these "as received" coals is above 50, very little if any improvement in coke strength or sizing can be expected by preheating the blend to as high as 450° F.

Three additional blends of these two coals were then studied with the medium-volatile constituent reduced to 15, 10 and 5 percent respectively. Stabilities of the cokes produced from the "as received" coals were 45.9, 35.9, and 33.6 respectively, in each case below 50, which for this study is considered a minimum strength index for satisfactory metallurgical coke.

When preheated, however, to 410° F, the first of these blends, which contained 15 percent medium-volatile coal, produced a coke with 50.5 stability. Coke from the second blend, containing 10 percent medium-volatile coal, produced coke with 53.4 stability when preheated at 300° F and 51.6 when preheated at 450°.

The final blend of coals studied in this series contained only 5 percent medium-volatile coal. Preheating to 440° F caused the stability to be increased to 52.3.

These data indicate that all blends of these Illinois No. 6 and medium-volatile coals in which the medium-volatile constituent ranged from 15 to as low as 5 percent, when coked in the "as received" condition, produce cokes with stabilities that are considered too low for metallurgical coke. However, by preheating these blends to temperatures ranging from 300° to 450° F before coking, satisfactory cokes with stability indices over 50 could be produced in all cases.

It has also been shown that each of these blends containing 15 percent or less of medium-volatile coal produced a significantly lower yield of minus 1 inch coke screenings when the blends were preheated. The greatest reduction in coke screenings occurred with the blend containing only 5 percent of medium-volatile coal.

Graphs showing the effects of preheating on coke stability in these tests are shown in figure 1, and complete coking data for the entire series are shown in tables A and B of the Appendix.

(B) Blends of Eastern Kentucky, Illinois No. 6 and Low-Volatile Pocahontas Coals

The first blend in the second series of tests included 35 percent of a high-volatile bituminous A rank coal from Eastern Kentucky, 40 percent of Illinois No. 6 Coal, and 25 percent of low-volatile Pocahontas coal. This blend was coked in the "as received" condition in sixteen hours. Coke stability was 55.5, a high value, which could probably not be improved by preheating.

When the amount of Pocahontas coal in this blend was reduced to 20 percent, with a corresponding increase to 40 percent in the Eastern Kentucky coal, the coke made from the "as received" coals had a stability of 52.3. Preheating at 350° F had no effect on coke stability, but further preheat at 450° F caused this index to increase slightly to 53.9

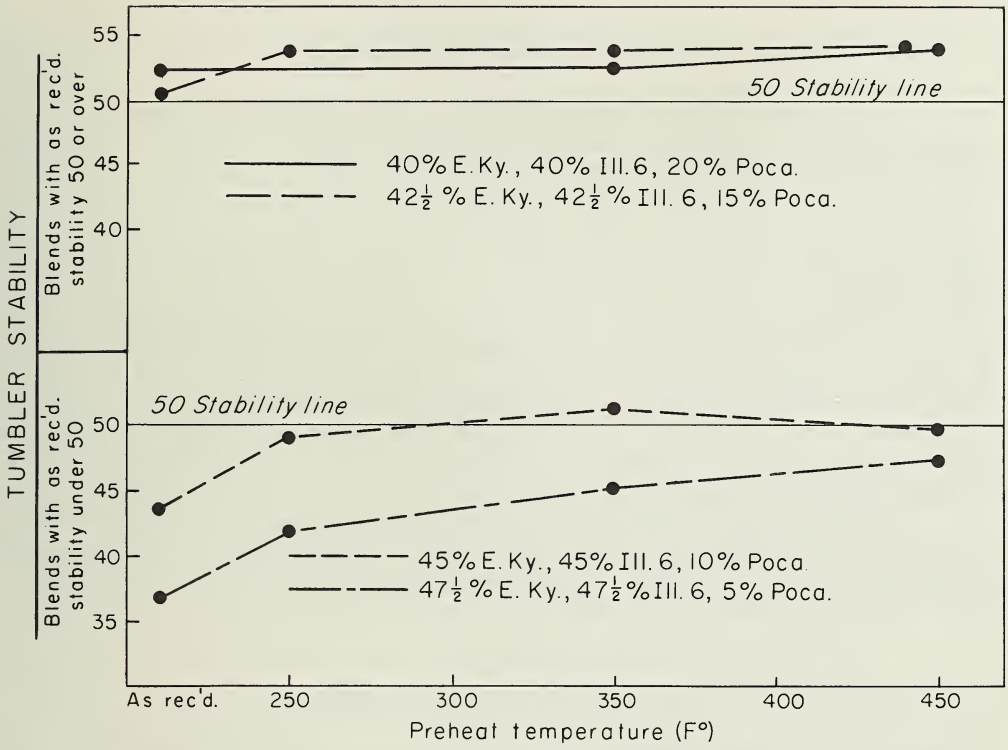


Fig. 2 - Effects of preheating blends of Eastern Kentucky, Illinois No. 6, and Pocahontas (1) coals.

The amount of Pocahontas coal in this series of blends was reduced further to 15 percent. Coke produced from the "as received" blend had a stability of 50.5; this was increased to between 53 and 54 by preheating the blend to a range of temperatures from 250° to 440° F. Although the original stability index of 50.5 probably warranted the use of this coke as blast furnace fuel, it is of interest to note that this index could be increased to a higher value by preheat.

Reducing the Pocahontas content still further to 10 percent had an appreciable effect on the stability of coke made from the "as received" coals, causing it to drop to 43.7. Preheating this blend increased the coke stability to a maximum of 51.4, an appreciable increase and one which would probably make this coke satisfactory for metallurgical use.

For a final test the Pocahontas content of this blend was reduced to 5 percent, and the blend was coked as before. Coke with a low stability of 36.8 was produced from the "as received" mixture. Preheating this blend to progressively higher temperatures caused coke stability to increase to a maximum of 47.1 with 450° preheat. While this value is not up to the limit of 50 set for this study, it does represent an increase of more than 10 in the stability index with preheating.

In this series of coking tests, the percentage of coke screenings (minus 1 inch) was reduced in each case when the coal blend was preheated. Coking time was reduced consistently, and coke-oven productivity increased as expected. The effects of preheating on coke stability in this series are shown graphically in figure 2, and complete coking data are shown in tables C and D of the Appendix.

(C) Blends of Eagle, Illinois No. 5, Petroleum Coke and Pocahontas

In the third series of coking tests, the low-volatile constituents in the blends consisted of petroleum coke and Pocahontas coal. Petroleum coke content was kept constant at 10 percent throughout the series until the final blend where it was reduced to 5 percent. Pocahontas content was decreased by 5 percent increments from 15 percent to zero. Eagle and Illinois No. 5 coals were present in equal percentages in all blends and were increased as the other constituents were decreased.

The first blend coked in this series contained 37.5 percent of Eagle, 37.5 percent of Illinois No. 5 Coal, 10 percent of petroleum coke and 15 percent of Pocahontas. A coke with 54.6 stability was produced from the "as received" coals. Preheating this blend to 450° F before coking reduced the coking time from 16 hours: 30 minutes to 12 hours but had very little effect on the originally high coke stability. Other coke physical properties were unaffected except for a reduction in the percentage of large coke produced and a small increase in coke screenings.

Reduction of the Pocahontas content of this blend to 10 percent resulted in a coke with a stability of 51.4 from the "as received" mixture. Preheating the blend to 260° F had no effect on coke stability, but subsequent preheating to 360° F caused a strong coke with 55.2 stability to be produced. Coking time

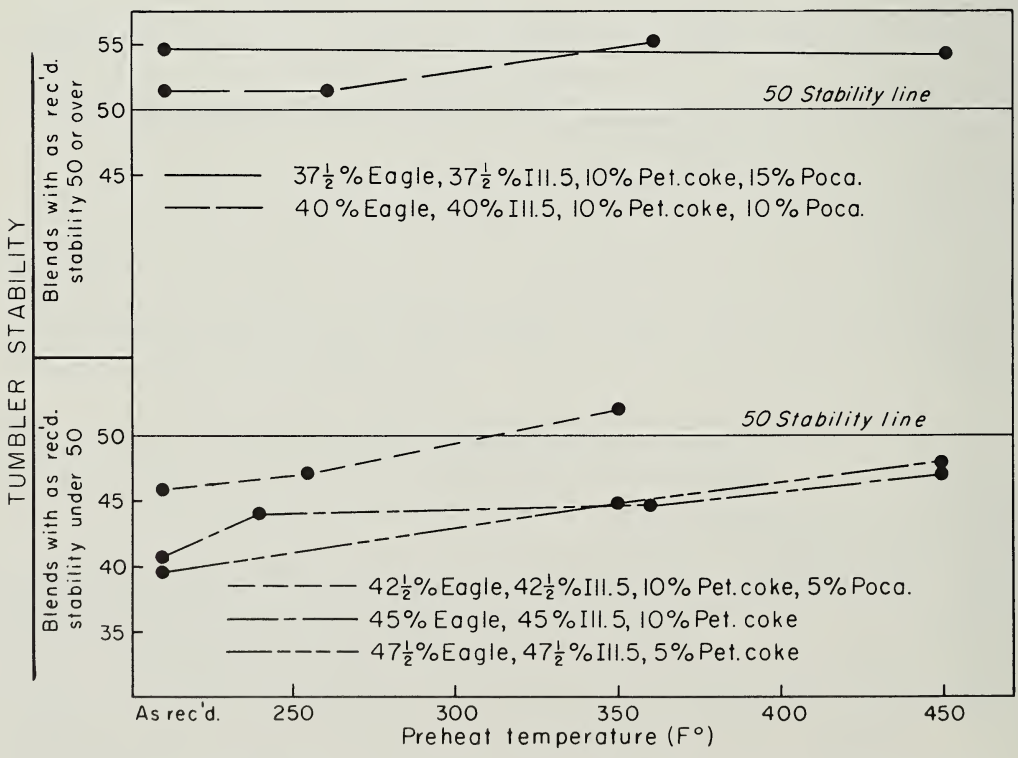


Fig. 3 - Effects of preheating blends of Eagle, Illinois No. 5, Pocahontas (2) coals, and petroleum coke.

was reduced from 15 hours to 12 hours: 40 minutes, and coke-oven productivity increased nearly 23 percent. This blend was not preheated to a temperature higher than 360° F.

Further reduction of the Pocahontas content to 5 percent, leaving a total of 15 percent low-volatile constituents in the blend, caused the stability of coke from the "as received" coals to drop to 45.9. Preheating this blend to a maximum of 350° F caused the coke stability to increase to 52.1. Minus 1 inch screenings remained practically constant.

In the next blend in this series, Pocahontas coal was eliminated entirely, leaving 10 percent of petroleum coke as the only low-volatile ingredient. Stability of the coke made from this blend of the "as received" coals was 40.7. Preheating to 450° F before coking caused this stability to increase to 47.1, an increase not great enough to qualify this coke as a good blast furnace fuel. Minus 1 inch screenings were decreased, however, from 6.3 to 4.9 percent of the total coke produced.

The final blend, in which the petroleum coke content was reduced to 5 percent, produced coke similar to that produced by the preceding blend. Preheating to 450° F caused coke stability to increase from 39.6 to 48.0. Minus 1 inch screenings were decreased from 5.9 to 5.0 percent of the total coke.

Coke stabilities obtained in this series of tests are plotted in figure 3, and complete coking data are shown in tables E and F of the Appendix.

SUMMARY AND CONCLUSIONS

In this study tests in the pilot coke oven showed the extent to which amounts of low-volatile constituents of three series of coal blends might be reduced without causing the stability index to fall below 50, which is assumed in these tests to be a minimum for satisfactory metallurgical coke.

In additional tests, coke strength was reduced further by greater reductions of the low-volatile constituents of these coal blends. It was found that after reducing the percentage of low-volatile coal, the stability of the coke that could be produced was often increased materially by first preheating the coal blends to temperatures ranging from 250° to 450° F. Cokes which had a tumbler stability of 50 or more without preheating the coal could not usually be strengthened appreciably by this procedure. However, cokes having stabilities lower than 50 were consistently made stronger by preheating the coal and often developed a satisfactory stability index of 50 or higher. It is indicated, therefore, that coal and coke costs might be reduced by incorporating less than the normal percentage of low-volatile coal into a coal blend while increasing coke-oven capacity and maintaining satisfactory coke stability by preheating the blend before coking.

It was also found that preheating coal usually reduced the percentage of minus 1 inch coke screenings produced when the coal was coked. Coke sizing was not otherwise affected appreciably. Other effects, such as reduced coking time and greater coke-oven productivity, have been reported in previous publications (Jackman and Helfinstine, 1968a, 1968b, and 1970) and are not discussed in detail here. However, all such coking data from these tests are shown in tables A through F of the Appendix.

REFERENCES

Jackman, H. W., and R. J. Helfinstine, 1968a, Drying and preheating coals before coking - Part 1. Individual coals: Illinois Geol. Survey Circ. 423, 26 p., and Blast Furnace and Steel Plant, v. 57, no. 2, p. 119-123, 1969.

Jackman, H. W., and R. J. Helfinstine, 1968b, Drying and preheating coals before coking - Part 2. Coal blends: Illinois Geol. Survey Circ. 434, 21 p.

Jackman, H. W., and R. J. Helfinstine, 1970, Heat drying coals at moderate temperatures before coking: Illinois Geol. Survey Circ. 449, 18 p.

APPENDIX

Tables A through F of this section present the complete pilot-plant coking results for each of the coal blends studied. Data include coking time, dry-coal bulk densities, coke physical properties, coke yields, expansion pressures, moisture in "as received" and predried coal blends, and the effect of predrying on the productivity of the coke oven.

TABLE A – RESULTS OF COKING TESTS ON BLENDS OF ILLINOIS NO. 6 AND MEDIUM-VOLATILE POCAHONTAS COALS

	Coal blend							
	70% Ill. 6 30% Med.-Vol. Poca.		80% Ill. 6 20% Med.-Vol. Poca.			85% Ill. 6 15% Med.-Vol. Poca.		
	Condition of coal							
	As rec'd.	Preheat 450°	As rec'd.	Preheat 350°	Preheat 450°	As rec'd.	Preheat 250°	Preheat 410°
	Run number							
	1205 E	1208 E	1209 E	1227 E	1210 E	1223 E 1229 E	1224 E	1225 E
Coking time (hr:min)	17:00	12:30	17:45	13:20	12:55	18:20	15:30	13:20
Bulk density (lb dry coal per cu ft)	43.7	47.0	45.3	46.5	46.7	46.6	46.7	45.0
Coke physical properties								
Tumbler test								
Stability	56.8	55.9	54.3	52.7	53.2	45.9	48.9	50.5
Hardness	66.6	68.0	66.6	64.5	65.5	66.1	66.6	64.8
Shatter test								
+2"	70.0	63.0	68.0	69.2	63.0	62.4	66.8	70.2
+1½"	91.0	90.0	88.0	90.0	90.0	85.0	87.0	87.8
+1"	95.8	95.8	95.0	94.0	94.8	93.4	94.4	94.4
Sizing (%)								
+3"	32.2	31.8	34.1	33.2	31.8	28.9	31.6	34.8
3" x 2"	42.4	41.9	41.3	41.2	42.4	43.8	43.3	41.1
2" x 1"	20.1	21.2	18.9	19.7	20.3	20.9	19.5	18.5
minus 1"	5.3	5.1	5.7	5.9	5.5	6.4	5.6	5.6
Apparent gravity	0.79	0.81	0.775	0.795	0.78	0.78	0.78	0.835
Coke yields (% of dry coal)								
Total (dry)	71.7	71.5	70.0	70.4	70.5	70.3	69.0	69.4
Furnace (+1") (dry)	67.9	67.8	66.0	66.3	66.7	65.8	65.1	65.2
Screenings (dry)	3.8	3.7	4.0	4.1	3.8	4.5	3.9	4.2
Expansion pressure (lb per sq in.)	0.35	0.70	0.4	1.05	1.65	0.4	0.45	0.75
% moisture in coal as charged*	8.2	–0.8	7.6	–0.4	–0.9	8.2	2.4	–0.4
Coke oven capacity								
Coal charges per oven/24 hr	1.41	1.92	1.35	1.8	1.86	1.31	1.55	1.80
Lb furnace coke per cu ft/24 hr	41.8	61.1	40.4	55.5	58.0	40.2	47.1	52.8
% increase in furnace coke (compared with coal "as received")	–	46.2	–	37.4	43.5	–	17.1	31.4

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

TABLE B - RESULTS OF COKING TESTS (CONT.) ON BLENDS OF ILLINOIS NO. 6 AND MEDIUM-VOLATILE POCAHONTAS COALS

	Coal blend						
	90% Ill. 6 10% Med.-Vol. Poca.				95% Ill. 6 5% Med.-Vol. Poca.		
	Condition of coal						
	As rec'd.	Preheat 300°	Preheat 350°	Preheat 450°	As rec'd.	Preheat 330°	Preheat 440°
	Run number						
	1211 E	1230 E	1213 E	1212 E	1215 E	1231 E 1216 E	1214 E
Coking time (hr:min)	18:30	14:30	14:00	13:15	18:30	13:40	12:30
Bulk density (lb dry coal per cu ft)	47.2	47.3	47.0	47.2	46.1	47.25	47.2
Coke physical properties							
Tumbler test							
Stability	35.9	53.4	50.5	51.6	33.6	49.0	52.3
Hardness	68.2	68.4	66.4	65.2	68.6	67.3	67.1
Shatter test							
+2"	49.0	60.8	70.0	69.0	50.0	60.9	64.0
+1½"	76.0	86.0	87.0	87.0	78.0	82.5	85.0
+1"	90.2	95.0	95.0	94.0	91.0	93.6	94.0
Sizing (%)							
+3"	18.5	26.1	28.9	34.5	17.7	26.0	27.7
3" x 2"	45.4	46.8	45.8	40.5	42.1	46.0	45.2
2" x 1"	28.9	21.1	19.7	19.0	32.7	21.7	21.3
minus 1"	7.2	6.0	5.6	6.0	7.5	6.3	5.8
Apparent gravity	0.78	0.78	0.785	0.765	0.745	0.77	0.755
Coke yields (% of dry coal)							
Total (dry)	69.8	69.7	69.6	69.7	69.5	69.1	68.3
Furnace (+1") (dry)	64.8	65.7	65.6	65.5	64.2	64.8	64.2
Screenings (dry)	5.0	4.0	4.0	4.2	5.3	4.3	4.1
Expansion pressure (lb per sq in.)	0.4	0.8	1.5	2.2	0.25	0.9	1.45
% moisture in coal as charged*	7.6	0.6	-0.2	-0.7	8.9	-0.1	-1.5
Coke oven capacity							
Coal charges per oven/24 hr	1.3	1.65	1.71	1.81	1.29	1.75	1.92
Lb furnace coke per cu ft/24 hr	39.7	51.3	52.6	56.0	38.2	53.6	58.2
% increase in furnace coke (compared with coal "as received")	-	29.2	32.5	41.0	-	40.3	52.4

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

TABLE C – RESULTS OF COKING TESTS ON BLENDS OF EASTERN KENTUCKY, ILLINOIS NO. 6, AND LOW-VOLATILE POCAHONTAS (1) COALS

	Coal blend							
	35% E. Ky. 40% Ill. 6 25% Poca.(1)	40% E. Ky. 40% Ill. 6 20% Poca.(1)			42½% E. Ky. 42½% Ill. 6 15% Poca.(1)			
	Condition of coal							
	As rec'd.	As rec'd.	Preheat 350°	Preheat 450°	As rec'd.	Preheat 250°	Preheat 350°	Preheat 440°
	Run number							
	1252 E	1251 E	1347 E	1348 E	1256 E	1267 E	1259 E	1260 E
Coking time (hr:min)	16:00	16:00	13:00	12:00	16:10	14:45	13:30	12:30
Bulk density (lb dry coal per cu ft)	45.0	44.8	48.0	48.2	48.7	47.3	47.5	47.4
Coke physical properties								
Tumbler test								
Stability	55.5	52.3	52.3	53.9	50.5	53.9	53.7	53.7
Hardness	65.5	64.8	64.5	64.4	66.0	67.0	65.9	66.8
Shatter test								
+2"	75.0	74.0	77.0	75.6	68.8	70.8	69.6	66.4
+1½"	91.6	90.0	91.0	90.0	88.8	89.0	89.0	89.6
+1"	96.2	96.0	96.0	96.4	95.2	95.6	96.0	95.2
Sizing (%)								
+3"	43.8	36.8	42.3	41.4	37.4	36.6	40.5	36.8
3" x 2"	34.8	38.5	37.3	37.8	39.6	41.2	36.7	39.8
2" x 1"	15.9	19.5	15.7	16.0	17.8	17.3	17.4	18.4
minus 1"	5.5	5.2	4.7	4.8	5.2	4.9	5.4	5.0
Apparent gravity	0.805	0.79	0.795	0.82	0.825	0.815	0.81	0.807
Coke yields (% of dry coal)								
Total (dry)	71.3	69.7	71.4	69.4	70.2	70.9	70.1	69.5
Furnace (+1") (dry)	67.4	66.1	68.0	66.2	66.6	67.4	66.3	66.0
Screenings (dry)	3.9	3.6	3.4	3.2	3.6	3.5	3.8	3.5
Expansion pressure (lb per sq in.)	0.4	0.3	0.75	0.72	0.82	0.52	0.83	0.81
% moisture in coal as charged*	4.8	5.4	0.0	-1.0	4.8	1.0	0.6	-1.1
Coke oven capacity								
Coal charges per oven/24 hr	1.50	1.50	1.84	2.00	1.48	1.63	1.78	1.92
Lb furnace coke per cu ft/24 hr	45.5	44.4	60.1	63.7	48.0	52.0	56.0	60.0
% increase in furnace coke (compared with coal "as received")	–	–	35.4	43.5	–	8.3	16.6	25.0

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

TABLE D - RESULTS OF COKING TESTS (CONT.) ON BLENDS OF EASTERN KENTUCKY, ILLINOIS NO. 6, AND LOW-VOLATILE POCAHONTAS (1) COALS

	Coal blend							
	45% E. Ky. 45% Ill. 6 10% Poca.(1)				47½% E. Ky. 47½% Ill. 6 5% Poca.(1)			
	Condition of coal							
	As rec'd.	Preheat 250°	Preheat 350°	Preheat 450°	As rec'd.	Preheat 250°	Preheat 350°	Preheat 450°
	Run number							
	1257 E	1266 E	1261 E	1262 E	1258 E	1265 E	1263 E	1264 E
Coking time (hr:min)	16:30	14:45	13:30	12:30	16:45	14:30	13:20	12:30
Bulk density (lb dry coal per cu ft)	48.2	47.7	48.8	46.3	45.0	47.3	48.4	47.8
Coke physical properties								
Tumbler test								
Stability	43.7	49.1	51.4	49.6	36.8	41.9	45.2	47.1
Hardness	66.2	66.4	65.7	65.0	64.1	65.3	65.5	64.5
Shatter test								
+2"	63.8	66.0	66.8	69.2	52.8	58.0	61.8	58.8
+1½"	86.2	88.0	87.6	87.6	81.0	84.0	83.8	84.0
+1"	93.2	95.0	94.2	95.0	91.2	93.0	93.2	93.6
Sizing (%)								
+3"	30.7	40.2	40.0	38.3	29.3	32.3	35.2	36.5
3" x 2"	43.6	38.0	36.3	36.5	40.5	41.1	38.7	37.2
2" x 1"	19.4	16.4	18.2	19.7	23.8	20.7	19.7	20.4
minus 1"	6.3	5.4	5.5	5.5	6.4	5.9	6.4	5.9
Apparent gravity	0.815	0.795	0.81	0.78	0.765	0.795	0.785	0.79
Coke yields (% of dry coal)								
Total (dry)	69.7	69.2	69.2	69.3	68.0	69.3	68.3	67.1
Furnace (+1") (dry)	65.3	65.5	65.5	65.5	63.7	65.2	64.0	63.2
Screenings (dry)	4.4	3.7	3.7	3.8	4.3	4.1	4.3	3.9
Expansion pressure (lb per sq in.)	0.45	0.50	0.95	0.6	0.2	0.45	0.60	0.85
% moisture in coal as charged*	5.0	0.8	-0.1	-0.6	5.2	1.5	-0.4	-0.5
Coke oven capacity								
Coal charges per oven/24 hr	1.45	1.63	1.78	1.92	1.43	1.65	1.80	1.92
Lb furnace coke per cu ft/24 hr	45.6	50.9	56.9	58.2	41.0	50.9	55.8	58.0
% increase in furnace coke (compared with coal "as received")	-	11.6	24.8	27.6	-	24.1	36.1	41.5

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

TABLE E – RESULTS OF COKING TESTS ON BLENDS OF EAGLE, ILLINOIS NO. 5, LOW-VOLATILE POCAHONTAS (2) COALS, AND PETROLEUM COKE

	Coal blend							
	37½% Eagle 37½% Ill. 5 10% Pet. Coke 15% Poca.(2)		40% Eagle 40% Ill. 5 10% Pet. Coke 10% Poca. (2)			42½% Eagle 42½% Ill. 5 10% Pet. Coke 5% Poca. (2)		
	Condition of coal							
	As rec'd.	Preheat 450°	As rec'd.	Preheat 260°	Preheat 360°	As rec'd.	Preheat 255°	Preheat 350°
	Run number							
	1375 E	1391 E	1366 E	1367 E	1372 E	1360 E	1362 E	1361 E
Coking time (hr:min)	16:30	12:00	15:00	13:00	12:40	14:00	13:00	12:00
Bulk density (lb dry coal per cu ft)	48.8	49.9	46.4	49.4	48.2	44.2	48.0	46.9
Coke physical properties								
Tumbler test								
Stability	54.6	54.3	51.4	51.4	55.2	45.9	47.1	52.1
Hardness	65.3	65.2	62.3	64.6	66.2	60.7	63.0	65.0
Shatter test								
+2"	74.4	68.8	75.6	75.0	73.2	74.8	66.4	71.6
+1½"	91.0	90.0	90.8	90.0	89.0	88.8	85.0	88.8
+1"	96.0	96.0	95.2	95.0	95.0	95.0	94.8	95.0
Sizing (%)								
+3"	50.0	40.7	48.6	44.2	46.9	43.5	47.2	44.4
3" x 2"	34.2	37.6	35.1	36.8	34.4	36.8	32.7	36.5
2" x 1"	11.9	17.3	11.5	14.0	14.1	14.4	14.6	13.9
minus 1"	3.9	4.4	4.8	5.0	4.6	5.3	5.5	5.2
Apparent gravity	0.87	0.86	0.845	0.885	0.85	0.82	0.85	0.84
Coke yields (% of dry coal)								
Total (dry)	73.9	73.7	73.4	72.4	73.1	72.2	72.5	72.5
Furnace (+1") (dry)	71.0	70.5	69.8	68.8	69.7	68.4	68.5	68.8
Screenings (dry)	2.9	3.2	3.6	3.6	3.4	3.8	4.0	3.7
Expansion pressure (lb per sq in.)	0.5	0.9	0.5	0.55	0.55	0.2	0.4	0.45
% moisture in coal as charged*	4.5	0.0	5.1	0.5	0.9	5.5	0.6	0.0
Coke oven capacity								
Coal charges per oven/24 hr	1.45	2.0	1.60	1.85	1.89	1.71	1.85	2.00
Lb furnace coke per cu ft/24 hr	50.2	69.3	51.75	62.9	63.5	51.6	60.8	64.5
% increase in furnace coke (compared with coal "as received")	–	38.1	–	21.6	22.7	–	17.8	25.0

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

TABLE F - RESULTS OF COKING TESTS (CONT.) ON BLENDS OF EAGLE, ILLINOIS NO. 5, LOW-VOLATILE POCAHONTAS (2) COALS, AND PETROLEUM COKE

	Coal blend						
	45% Eagle 45% Ill. 5 10% Pet. Coke				47½% Eagle 47½% Ill. 5 5% Pet. Coke		
	Condition of coal						
	As rec'd.	Preheat 240°	Preheat 350°	Preheat 450°	As rec'd.	Preheat 360°	Preheat 450°
	Run number						
	1363 E	1364 E	1365 E	1377 E	1373 E	1374 E	1376 E
Coking time (hr:min)	14:30	13:30	12:15	11:30	15:10	12:30	11:45
Bulk density (lb dry coal per cu ft)	44.2	47.9	48.0	48.0	44.7	46.2	47.7
Coke physical properties							
Tumbler test							
Stability	40.7	44.1	44.8	47.1	39.6	44.8	48.0
Hardness	58.9	60.5	63.0	63.0	59.1	62.5	62.3
Shatter test							
+2"	73.0	73.0	67.4	70.0	73.4	69.0	68.6
+1½"	87.2	87.0	85.4	87.0	88.2	87.6	88.4
+1"	94.0	93.0	94.0	95.0	93.8	94.0	94.0
Sizing (%)							
+3"	47.7	50.5	49.8	46.9	46.6	49.1	46.1
3" x 2"	33.6	31.5	31.4	33.0	33.6	32.4	33.0
2" x 1"	12.4	12.2	13.5	15.2	13.9	13.2	15.9
minus 1"	6.3	5.8	5.3	4.9	5.9	5.3	5.0
Apparent gravity	0.84	0.83	0.86	0.835	0.82	0.845	0.835
Coke yields (% of dry coal)							
Total (dry)	72.5	71.7	71.5	70.2	71.1	72.3	70.8
Furnace (+1") (dry)	68.0	67.5	67.7	66.8	66.9	68.5	67.2
Screenings (dry)	4.5	4.2	3.8	3.4	4.2	3.8	3.5
Expansion pressure (lb per sq in.)	0.25	0.4	0.45	0.45	0.2	0.55	0.55
% moisture in coal as charged*	5.6	1.3	0.0	-0.6	6.1	-0.2	-0.6
Coke oven capacity							
Coal charges per oven/24 hr	1.65	1.78	1.96	2.09	1.58	1.92	2.04
Lb furnace coke per cu ft/24 hr	49.6	57.5	63.7	67.0	47.2	60.7	65.3
% increase in furnace coke (compared with coal "as received")	-	16.1	28.7	35.0	-	28.6	38.4

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

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