STATE OF ILLINOIS
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DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

COKING COALS of ILLINOIS

Their Use in Blends for Metallurgical Coke

H. W. Jackman
R. L. Eissler
F. H. Reed

DIVISION OF THE
ILLINOIS STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief* URBANA

CIRCULAR 219 1956

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ABSTRACT

Pilot-plant coking tests on blends of Illinois and eastern coals have shown that Illinois coals exert a relatively low expansion pressure and may be added to expanding coal blends to reduce the pressure exerted on coke-oven walls. Addition of Illinois coal tends to increase coke stability except where the original coke is exceptionally strong.

Favorable freight rates from southern Illinois coal fields to the Chicago and St. Louis districts result in reduced coal costs and savings in the cost of coke.

ILLINOIS COAL USED IN COKE

Coal from the Illinois No. 6 seam has been used continuously for production of blast furnace coke since 1944 when it was first blended with No. 3 Pocahontas coal and charged to coke ovens in the Koppers Company plant at Granite City, Illinois. The company tested No. 5 coal at the same time, and since 1949 has used blends that contain both No. 5 and No. 6 coals. No. 5 coal has been used also by a Chicago district coke plant since 1948.

The first blends used at Granite City consisted of two coals, Illinois No. 6 and Pocahontas, with the proportion of Illinois coal varied from 60 to 75 percent over several test periods. During that time the plant operated one battery of 49 Koppers Underjet ovens of 17 tons capacity, having an average width of 17 inches with a 3-inch taper. Coke from the initial test ovens pushed easily and showed high tumbler stability and hardness factors of 55 and 65 respectively. Owing in part to the long coking time of 24 hours, the coke was large, about 25 percent of it passing over a 4-inch screen.

The blast furnace in use during the initial testing period had a hearth diameter of 17 feet 9 inches. The first Illinois coke to be used as blast furnace fuel caused a small reduction in iron tonnage and a considerable increase in coke rate. Within a short time a second blast furnace was placed in operation. To supply the additional coke requirements, coking time was reduced to about 17 hours, which resulted in a smaller sized coke and improved blast furnace efficiency.

Coke from the blends of No. 6 coal and Pocahontas coal remained consistently rough in appearance and contained pebbly seams that were easily abraded. It was decided to add 20 percent of a highly fluid eastern high-volatile coal to improve the plastic properties of the blend and eliminate the pebbly structure. The resulting coke was smoother in appearance and smaller in size. Blast furnace practice again improved.

The final major change in coal-blending procedure was substitution of Illinois No. 5 coal for the eastern high-volatile coal. The resulting coke retained its satisfactory surface structure and the stability increased to the high 50's. Coke size remained relatively small. Blast furnace practice improved and set new production records that included high iron tonnage at normal coke rates. This type of coal blend is still used and gives satisfactory operating results in both coke ovens and blast furnaces.

This brief account of the development of a satisfactory coal blend using coals indigenous to the area has been given to illustrate what may be accomplished when the financial incentive is sufficient to warrant continuous effort until desired results are attained.

Much of the research behind the development of the coal blend at Granite City, and of other blends utilizing Illinois coals, has been carried out in the laboratories and pilot coke ovens at the Illinois State Geological Survey. The original slot-type oven (Reed, 1947) and the newer movable-wall oven (Jackman, 1955a) have been developed and operated so that coking results closely duplicate those obtained in commercial oven practice. Results of tests made with the pilot oven may be used, therefore, as a dependable guide to anticipate performance of an experimental coal blend in commercial ovens.

We wish to thank the coke and steel companies that have furnished us with coals for these tests, and Illinois coal producers who furnished the No. 5 and No. 6 seam coals. We are grateful also to those of our own staff who have cooperated in obtaining samples, operating the pilot oven, and making analyses of all coals and cokes.

SCOPE OF PROJECT

Pilot-plant studies with the movable-wall oven have been made to determine the effect of blending Illinois coals in relatively small percentages with eastern high-volatile coals now used for coke in the Chicago district. Seven eastern coals, from eastern Kentucky, West Virginia, and Virginia, that ranged in volatile matter from 29 to 39 percent were studied.

In previous tests we had observed that the addition of Illinois coal to an eastern blend frequently caused the pressure against coke-oven walls to be reduced during the coking period. Too, many of the cokes were made stronger by the addition of Illinois coal. We wished therefore to determine to what extent Illinois coals could be used with eastern coals to reduce expansion pressure on the oven walls and to increase the strength of the coke.

Illinois coals for metallurgical coke are mined within 300 miles of Chicago and 100 miles of St. Louis, whereas the eastern coals originate some 600 miles away. Freight rates on Illinois coals delivered to Chicago and St. Louis therefore are lower than on eastern coals, even though the eastern coal may be delivered to Chicago by lake boat and Illinois coal must be delivered by rail.

The Illinois coals as prepared for the steel industry contain 6 to 8 percent moisture. As this is higher than the normal moisture content of eastern coking coals, the yield of dry coke is lowered correspondingly. Giving consideration to freight rates and coke yields, we wished to determine to what extent the use of Illinois coals by the coke industry could reduce over-all freight charges on coal, and what such savings would mean per ton of furnace coke produced.

PROCEDURE

To evaluate Illinois coals in blends with coals from the East, each high-volatile coal, including those from Illinois and the eastern fields, was tested individually in a blend with 25 percent Pocahontas coal. Each eastern high-volatile coal was then tested in a blend with 25 percent Illinois No. 5 and 25 percent Pocahontas, and next in a similar blend in which Illinois No. 6 replaced the No. 5 coal. All tests were made under identical operating conditions in the movable-wall oven.

During each coking test a continuous record was made of the total pressure exerted on the movable wall. The peak pressure, which occurs at about the time the plastic zones meet at the center of the oven, was converted into pounds per square inch of wall area and reported as expansion pressure.

Each batch of experimental coke produced, amounting to about 450 pounds, was quenched, heat dried, sized, and sampled. Coke yields were determined, and physical and chemical tests made. Analyses of coal blends and cokes are shown in the Appendix (tables A to H).

Each eastern coal tested was obtained in sufficient quantity for the pilot-oven tests from the plant in which it is normally used. Illinois coals were obtained from the producing mines, and low-volatile Pocahontas for blending came from the Granite City plant.

RESULTS OF TESTS

The first tests in the experimental oven were made on the blends of Illinois coals with Pocahontas coal. Analyses and plastic properties of the Illinois coals are shown in table 1, and similar data for the Pocahontas coal used in all blends are shown in table 2. Following the individual tests on No. 5 and No. 6 coals, a third blend was coked containing both these Illinois coal seams in the proportions used at Granite City.

Table 1. - Illinois Coals Used Throughout This Study
Analyses and Plastic Properties

Analyses

		Moisture-free basis				
Coal seam	M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
Illinois No. 5 (3" x 1½" washed) Average - 7 samples	6.3	36.9	55.8	7.3	1.44	6
Illinois No. 6 (3" x 1½" washed) Average - 5 samples	8.7	38.5	53.6	7.9	1.15	4½

Plastic Properties

	Gieseler fluidity		Plastic range (°C.)	
	Dial div. per min.	at °C.	Softening	Solidification
Illinois No. 5	71	433	389	462
Illinois No. 6	26	426	379	454

Table 2. - Pocahontas Coal Used in All Blends
Analysis and Plastic Properties

Analysis

M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
	Moisture-free basis				
3.2	16.9	75.5	7.6	0.78	9

Plastic Properties

Gieseler fluidity Dial div. per min.	at °C.	Plastic range (°C.) Softening	Solidification
10	477	442	503

Blends with Coals from Illinois

Results of these tests, shown in table 3, indicate that the Illinois coals exert a relatively low pressure on coke-oven walls. Pressure exerted by the No. 6 coal blend is especially low, less than one pound per square inch. No. 5 coal blend exerts a pressure of 1.4 pounds per square inch, still well under the maximum pressure considered safe for commercial oven operation. The blend containing both coal seams exerted an intermediate wall pressure and produced very strong coke with good size distribution and a low percentage of fines. Tests on the experimental cokes correspond closely with tests on commercial coke made at the Granite City plant.

As stated above, inclusion of No. 5 seam coal eliminates the rough coke structure produced by No. 6 and Pocahontas coals alone. At present, however, certain No. 6 coal mines are producing coal that has greater fluidity in the plastic state than the No. 6 coals used in the war years. No commercial plant is operating on a blend that contains only No. 6 and Pocahontas coals, but pilot-plant tests indicate that such a blend today might have less tendency to produce large, irregularly shaped coke with pebbly seams like that produced originally at Granite City.

Other recent pilot-plant tests indicate that the rough coke structure might be eliminated entirely by blending the No. 6 with certain coals of about 22 percent volatile matter instead of the usual low-volatile Pocahontas. Such coals studied in our laboratories have a relatively high Gieseler fluidity which counterbalances the low fluidity of the No. 6 coal. Results of tests with one such medium-volatile coal are shown in tables I, J, and K of the Appendix.

Table 3. - Coking Tests on Illinois Coal Blends

	75% Ill. No. 5 25% Pocahontas Runs 93-94	75% Ill. No. 6 25% Pocahontas Runs 84-85	55% Ill. No. 6 20% Ill. No. 5 25% Pocahontas Run 136
Expansion pressure			
Lbs. per sq. in.	1.40	0.64	0.83
Bulk density (lbs. per cu. ft.)	49.9	50.2	50.3
Coke physical properties			
Tumbler test			
Stability	55.4	54.5	55.9
Hardness	66.5	64.4	65.5
Shatter test			
+2"	80.9	81.8	82.0
+1½"	92.7	93.0	93.5
+1"	97.7	97.3	97.2
Coke Sizing			
+4"	5.4	8.4	6.2
4" x 3"	18.5	26.8	24.8
3" x 2"	48.4	42.3	44.1
2" x 1"	21.7	15.9	18.8
1" x ½"	2.3	1.7	1.7
-½"	3.7	4.9	4.4
Av. size (in.)	2.45	2.63	2.56
Apparent gravity	0.82	0.79	0.80
Coke yields (% of coal as charged)			
Total	70.5	67.3	68.6
Furnace (+1")	66.2	62.9	64.5
Nut and pea (1" x ½")	1.6	1.2	1.2
Breeze (-½")	2.7	3.2	2.9
Operating data			
Pulverization (-1/8")	80.6	79.5	79.3
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	17	17	16

Blends with Coals from Eastern Kentucky

Three eastern Kentucky coals were studied, first blended with Pocahontas alone and then with Pocahontas and the Illinois coals. All the Kentucky coals are well known in the industry so we will designate them A, B, and C. Each coal is from a different seam, and although all are mined within the same general area the coals have markedly different coking characteristics. Analyses and plastic properties of the Kentucky coals are shown in table 4. Coking results in the pilot oven for each of the three series of tests are shown in tables 5, 6, and 7.

Expansion Pressure. - Eastern Kentucky A and B coals in blends with Pocahontas are shown to exert a low wall pressure of one pound per square inch or less, and the C blend exerts roughly twice that pressure. Expansion pressures are not affected appreciably by the addition of Illinois No. 5 coal to the blends. However, addition of No. 6 coal consistently lowered the pressure: by 0.1 pound per square inch for the Kentucky A and B blends, and by 0.5 pound, or over 30 percent, for the Kentucky C blend.

Coke Physical Properties. - The effect of the Illinois coals on coke properties can be seen best by studying the tables. Generally speaking, both Illinois coals improved the tumbler stability, and had only minor effects on coke size and shatter indices. Both coals caused a reduction in apparent gravity, No. 6 more than No. 5. Both Illinois coals reduced the yield of furnace coke, No. 5 coal by an average of 0.6 percent, and No. 6 by 1.9 percent. The percentage of minus 1-inch-size coke was also reduced in five of the six tests by an average of 0.6 percent.

Coke Analyses. - It is not possible to generalize freely regarding the effect of Illinois coals on the coke analyses except to point out that coke ash is in all cases approximately equal to the computed values based on coal ash and coke yields. Eastern Kentucky A coal contained about the same percentage of

Table 4. - Eastern Kentucky Coals Studiea
Analyses and Plastic Properties

Analyses

		Moisture-free basis				
	M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
Kentucky A	2.3	37.3	55.5	7.2	0.72	$6\frac{1}{2}$
Kentucky B	2.3	38.7	57.7	3.6	0.51	7
Kentucky C	2.9	38.5	57.4	4.1	0.86	5

Plastic Properties

	Gieseler fluidity Dial div.	at °C.	Plastic range Softening	Solidification
Kentucky A	4412	442	393	475
Kentucky B	2143	439	394	474
Kentucky C	232	445	402	471

Table 5. - Coking Tests on Eastern Kentucky A and Illinois Coal Blends

	75% E. Ky. A 25% Pocahontas Run 123	50% E. Ky. A 25% Ill. No. 5 25% Pocahontas Run 124	50% E. Ky. A 25% Ill. No. 6 25% Pocahontas Run 126
Expansion pressure			
Lbs. per sq. in.	1.00	0.94	0.86
Bulk density (lbs. per cu. ft.)	52.3	51.9	51.5
Coke physical properties			
Tumbler test			
Stability	40.2	43.9	46.8
Hardness	62.2	63.4	63.4
Shatter test			
+2"	76.5	77.5	80.0
+1½"	89.0	89.7	91.3
+1"	95.5	95.6	96.2
Coke sizing			
+4"	10.2	6.8	6.6
4" x 3"	37.3	29.9	28.5
3" x 2"	28.8	36.7	37.6
2" x 1"	16.2	20.6	21.2
1" x ½"	3.2	1.6	2.0
-½"	4.3	4.4	4.1
Av. size (in.)	2.76	2.60	2.58
Apparent gravity	0.87	0.865	0.86
Coke yields (% of coal as charged)			
Total	72.1	70.5	70.5
Furnace (+1")	66.7	66.3	66.2
Nut and pea (1" x ½")	2.3	1.1	1.4
Breeze (-½")	3.1	3.1	2.9
Operating data			
Pulverization (-1/8")	76.8	78.2	78.6
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:30	16:30	16:30

Table 6. - Coking Tests on Eastern Kentucky B and Illinois Coal Blends

	75% E. Ky. B 25% Pocahontas Run 132	50% E. Ky. B 25% Ill. No. 5 25% Pocahontas Run 133	50% E. Ky. B 25% Ill. No. 6 25% Pocahontas Run 131
Expansion pressure			
Lbs. per sq. in.	0.83	0.94	0.76
Bulk density (lbs. per cu. ft.)	50.2	50.2	50.2
Coke physical properties			
Tumbler test			
Stability	51.1	53.1	53.6
Hardness	65.8	66.1	64.8
Shatter test			
+2"	70.5	70.4	79.5
+1½"	90.7	90.3	92.6
+1"	97.0	96.2	96.7
Coke sizing			
+4"	5.9	3.6	4.6
4" x 3"	18.3	27.4	33.5
3" x 2"	43.7	39.7	37.4
2" x 1"	26.4	23.8	18.2
1" x ½"	2.0	1.8	2.0
-½"	3.7	3.7	4.3
Av. size (in.)	2.42	2.49	2.61
Apparent gravity	0.86	0.85	0.84
Coke yields (% of coal as charged)			
Total	70.9	70.1	70.0
Furnace (+1")	66.9	66.3	65.6
Nut and pea (1" x ½")	1.4	1.2	1.4
Breeze (-½")	2.6	2.6	3.0
Operating data			
Pulverization (-1/8")	76.3	79.1	76.4
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:00	16:00	16:00

Table 7. - Coking Tests on Eastern Kentucky C and Illinois Coal Blends

	75% E. Ky. C 25% Pocahontas Runs 139-142	50% E. Ky. C 25% Ill. No. 5 25% Pocahontas Run 141	50% E. Ky. C 25% Ill. No. 6 25% Pocahontas Run 140
Expansion pressure			
Lbs. per sq. in.	1.62	1.57	1.11
Bulk density (lbs. per cu. ft.)	54.0	53.9	53.6
Coke physical properties			
Tumbler test			
Stability	52.9	55.5	53.6
Hardness	69.4	69.2	67.9
Shatter test			
+2"	71.8	70.9	77.4
+1½"	89.8	90.3	91.9
+1"	96.3	96.5	97.0
Coke sizing			
+4"	4.4	4.1	6.1
4" x 3"	20.7	25.1	21.5
3" x 2"	40.4	39.0	44.1
2" x 1"	28.2	25.9	22.0
1" x ½"	1.5	1.7	1.5
-½"	4.8	4.2	4.8
Av. size (in.)	2.38	2.45	2.48
Apparent gravity	0.87	0.86	0.84
Coke yields (% of coal as charged)			
Total	69.8	68.7	68.0
Furnace (+1")	65.4	64.7	63.7
Nut and pea (1" x ½")	1.0	1.1	1.0
Breeze (-½")	3.4	2.9	3.3
Operating data			
Pulverization (-1/8")	84.2	83.9	82.7
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:30	16:30	16:30

ash as the Illinois coals, therefore the coke ash was not affected by additions of Illinois coal. Kentucky B and C coals were lower in ash, so that their coke ash was increased in proportion to the amount of Illinois coal used, the maximum increase amounting to 1.3 percent.

Illinois coals have a higher sulfur content than the eastern coals tested. This is true especially of the No. 5 seam, which showed a sulfur content of 1.44 percent. However, the Illinois coals are shown to lose a greater percentage of their sulfur during carbonization than do the Kentucky coals (table 13). Thus, the sulfur in the cokes made of Kentucky-Illinois blends is lower than would be expected from experience with Kentucky coals alone. In no case was sulfur in the coke increased by more than 0.13 percent by adding Illinois coal, the average increase being 0.06 percent.

Blends with Coals from West Virginia and Virginia

Coking tests similar to those described above were made with three coals from West Virginia and one from Virginia. The West Virginia coals were from an Eagle seam mine in Raleigh County and No. 2 Gas seam mines in Logan and Wyoming counties. The Virginia coal was from the Clintwood seam. Analyses and plastic properties of these eastern coals are shown in table 8, and results of the coking tests are given in tables 9 to 12 inclusive.

Expansion Pressure. - The pressure exerted by each of the blends of West Virginia high-volatile and Pocahontas coals is reduced by coal from both Illinois seams. Reductions due to No. 5 coal range from 50 percent for the Eagle blend to 28 and 21 percent, respectively, for the No. 2 Gas blends. Reductions in pressure attributed to No. 6 coal ranged from 65 percent with the Eagle blend to 36 and 21 percent, respectively, with the other two.

Table 8. - West Virginia and Virginia High-Volatile Coals
Analyses and Plastic Properties

		Analyses				
		Moisture-free basis				
	M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
Eagle - Raleigh Co.	0.8	29.5	64.8	5.7	0.66	8½
No. 2 Gas - Logan Co.	5.1	33.2	57.7	9.1	0.67	9
No. 2 Gas - Wyoming Co.	2.1	32.3	61.9	5.8	0.63	9
Clintwood - Dickenson Co.	4.7	32.9	62.7	4.4	0.86	9

Plastic Properties

	Gieseler fluidity		Plastic range (°C.)	
	Dial div. per min.	at °C.	Softening	Solidification
Eagle - Raleigh Co.	3,333	440	389	489
No. 2 Gas - Logan Co.	> 10,000	448	392	494
No. 2 Gas - Wyoming Co.	7,500	443	388	485
Clintwood - Dickenson Co.	*High	447	392	489

* Most of coal swelled out of cup.

Table 9. - Coking Tests on West Virginia Eagle (Raleigh County) and Illinois Coal Blends

	75% Eagle 25% Pocahontas Run 121	50% Eagle 25% Ill. No. 5 25% Pocahontas Run 122	50% Eagle 25% Ill. No. 6 25% Pocahontas Run 125
Expansion pressure			
Lbs. per sq. in.	2.57	1.31	0.89
Bulk density (lbs. per cu. ft.)	51.6	51.5	51.5
Coke physical properties			
Tumbler test			
Stability	60.5	58.5	58.5
Hardness	66.8	67.8	67.1
Shatter test			
+2"	83.0	79.0	80.7
+1½"	94.5	93.0	94.1
+1"	98.0	97.8	97.6
Coke sizing			
+4"	8.4	4.4	6.6
4" x 3"	40.3	25.8	37.6
3" x 2"	34.8	48.3	36.3
2" x 1"	11.6	16.7	14.8
1" x ½"	1.6	1.5	1.6
-½"	3.3	3.3	3.1
Av. size (in.)	2.85	2.58	2.87
Apparent gravity	0.89	0.895	0.88
Coke yields (% of coal as charged)			
Total	76.2	74.5	73.3
Furnace (+1")	72.5	70.9	69.9
Nut and pea (1" x ½")	1.2	1.1	1.1
Breeze (-½")	2.5	2.5	2.3
Operating data			
Pulverization (-1/8")	89.7	86.9	86.0
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:30	16:30	16:30

Table 10. - Coking Tests on West Virginia No. 2 Gas (Logan County) and Illinois Coal Blends

	75% No. 2 Gas 25% Pocahontas Run 158	50% No. 2 Gas 25% Ill. No. 5 25% Pocahontas Run 162	50% No. 2 Gas 25% Ill. No. 6 25% Pocahontas Run 159
Expansion pressure			
Lbs. per sq. in.	1.82	1.29	1.15
Bulk density (lbs. per cu. ft.)	54.4	53.0	53.1
Coke physical properties			
Tumbler test			
Stability	43.9	45.3	47.9
Hardness	59.5	60.5	61.2
Shatter test			
+2"	88.0	87.0	82.9
+1½"	94.0	93.6	92.9
+1"	96.8	96.4	96.5
Coke sizing			
+4"	16.5	17.9	19.1
4" x 3"	35.2	29.6	38.6
3" x 2"	31.1	33.8	25.4
2" x 1"	10.8	12.1	10.6
1" x ½"	2.3	2.2	2.1
-½"	4.1	4.4	4.2
Av. size (in.)	2.94	2.90	3.03
Apparent gravity	0.91	0.88	0.87
Coke yields (% of coal as charged)			
Total	74.5	72.4	72.2
Furnace (+1")	69.7	67.6	67.6
Nut and pea (1" x ½")	1.7	1.6	1.6
Breeze (-½")	3.1	3.2	3.0
Operating data			
Pulverization (-1/8")	83.4	83.9	84.5
Flue temp. (°F.)	1900	1900	1900
Coking time (hr.)	16:30	16:30	16:30

Table 11. - Coking Tests on West Virginia No. 2 Gas (Wyoming County) and Illinois Coal Blends

	75% No. 2 Gas 25% Pocahontas Run 143	50% No. 2 Gas 25% Ill. No. 5 25% Pocahontas Run 145	50% No. 2 Gas 25% Ill. No. 6 25% Pocahontas Run 146
Expansion pressure			
Lbs. per sq. in.	1.43	1.15	1.16
Bulk density (lbs. per cu. ft.)	53.9	53.9	53.6
Coke physical properties			
Tumbler test			
Stability	54.1	55.3	52.3
Hardness	67.1	67.1	66.8
Shatter test			
+2"	72.7	74.3	76.7
+1½"	92.0	91.5	91.3
+1"	97.0	97.0	97.0
Coke sizing			
+4"	9.2	6.4	6.2
4" x 3"	30.3	29.8	21.9
3" x 2"	36.6	37.5	46.4
2" x 1"	18.5	20.2	20.3
1" x ½"	1.7	2.1	1.7
-½"	3.7	4.0	3.5
Av. size (in.)	2.69	2.60	2.53
Apparent gravity	0.92	0.91	0.88
Coke yields (% of coal as charged)			
Total	73.6	72.4	71.2
Furnace (+1")	69.6	68.0	67.6
Nut and pea (1" x ½")	1.3	1.5	1.1
Breeze (-½")	2.7	2.9	2.5
Operating data			
Pulverization (-1/8")	87.5	86.3	84.0
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:30	16:30	16:30

Table 12. - Coking Tests on Virginia Clintwood (Dickenson County) and Illinois Coal Blends

	75% Clintwood 25% Pocahontas Run 163	50% Clintwood 25% Ill. No. 5 25% Pocahontas Run 165	50% Clintwood 25% Ill. No. 6 25% Pocahontas Run 166
Expansion pressure			
Lbs. per sq. in.	1.04	1.06	1.12
Bulk density (lbs. per cu. ft.)	52.1	52.1	52.3
Coke physical properties			
Tumbler test			
Stability	58.4	56.4	56.7
Hardness	67.2	67.4	65.5
Shatter test			
+2"	75.0	79.1	74.9
+1½"	93.8	94.6	91.8
+1"	97.6	97.7	96.9
Coke sizing			
+4"	2.8	5.6	4.5
4" x 3"	26.0	26.0	24.7
3" x 2"	45.2	41.2	47.9
2" x 1"	20.7	21.7	17.8
1" x ½"	1.5	1.6	1.7
-½"	3.8	3.9	3.4
Av. size (in.)	2.50	2.54	2.55
Apparent gravity	0.925	0.917	0.887
Coke yields (% of coal as charged)			
Total	72.6	71.2	71.0
Furnace (+1")	68.7	67.3	67.4
Nut and pea (1" x ½")	1.1	1.2	1.2
Breeze (-½")	2.8	2.7	2.4
Operating data			
Pulverization (-1/8")	89.3	86.8	86.0
Flue temp. (°F.)	1900	1900	1900
Coking time (hr.)	16:30	16:30	16:30

Virginia (Clintwood) coal blended with Pocahontas exerted a pressure of only 1.04 pounds per square inch. Neither of the Illinois coals had any significant effect on pressure when added to this blend.

Coke Physical Properties. - The properties of the cokes produced in this series of tests were not affected appreciably by the addition of Illinois coals except for a consistent reduction in apparent gravity, most pronounced in the blends with No. 6 coal. There was one exception in the Eagle coal tests in which No. 5 Illinois caused a small (perhaps insignificant) gravity increase. Tumbler and shatter indices were raised or lowered slightly, depending on the coal being tested. Average size of the cokes varied in minor amounts, usually within the range of experimental error. Illinois coal, owing in part to inherent moisture, caused furnace coke yields to be reduced from 1.3 to 2.6 percent, and in most cases caused a slight reduction in yield of the minus 1-inch sizes.

Coke Analyses. - Cokes made from blends of West Virginia and Virginia coals show the same analytical trends as do those containing the Kentucky coals. No. 2 Gas coal from Logan County is relatively high in ash so that Illinois coals lowered the ash content of the coke. The other eastern coals are lower in ash than those from Illinois. In no case was coke ash increased by more than 1 percent by Illinois No. 5 coal, or by more than 1.3 percent by Illinois No. 6.

The Illinois coals, which contained 1.15 and 1.44 percent sulfur, respectively, caused the coke sulfur to increase. However, as we found with the Kentucky blends, the Illinois coals lost a greater percentage of their sulfur during carbonization than did the eastern coals (table 13). The one exception to this trend occurred with the coke made from blends containing No. 2 Gas coal from Logan County. Coke sulfur was not increased, however, by more than 0.1 percent by either Illinois coal except for the Logan County blend with No. 5. This exception may have been the result of inaccurate sampling of the coke, but there is no proof.

FACTORS AFFECTING THE MINE COST AND QUALITY OF ILLINOIS COALS

The Illinois coals most suitable for metallurgical coke are mined in southern Illinois from thick, relatively flat seams. Mines employ the most modern methods of mechanical mining and coal preparation, producing coals of uniform ash and sulfur content. Seam thickness ranges from 5 feet in the No. 5 coal mines in Saline County to from 6 to more than 9 feet in No. 6 mines in Franklin, Williamson, and Jefferson counties.

Both the No. 5 and No. 6 seams are continuous throughout large areas of the State. Coals from southern Illinois mines operating in the same seam are of similar quality and may be mixed without regard to the originating mines. The various mine sizes, with the exception of the fines, also may be mixed or substituted for each other without appreciable effect on coke properties or yields (Jackman, 1955b).

Illinois coal fines are not used for coke production as they tend to be higher in ash, sulfur, and the non-coking ingredient, fusain. Bands of fusain occurring in the coal seams are soft and friable. During mining and screening operations they disintegrate so that the fusain is found mainly in the extremely fine sizes of coal. We have not determined the minimum size that may be used

Table 13. - A Study of Coal and Coke Sulfur

Blend	Sulfur % in coal (as received)	Yield of dry coke (% of coal as rec'd)	Sulfur % in coke (dry)	Coal sulfur % remaining in coke
75% Ill. No. 5 25% Pocahontas	1.15	70.5	0.94	57.6
75% Ill. No. 6 25% Pocahontas	1.05	67.3	0.83	53.2
55% Ill. No. 6 20% Ill. No. 5 25% Pocahontas	0.99	68.6	0.78	54.0
75% E. Ky. A 25% Pocahontas	0.71	72.1	0.65	66.0
50% E. Ky. A 25% Ill. No. 5 25% Pocahontas	0.86	70.5	0.73	59.8
50% E. Ky. A 25% Ill. No. 6 25% Pocahontas	0.81	70.5	0.68	59.2
75% E. Ky. B 25% Pocahontas	0.57	70.9	0.53	66.0
50% E. Ky. B 25% Ill. No. 5 25% Pocahontas	0.78	70.1	0.66	59.3
50% E. Ky. B 25% Ill. No. 6 25% Pocahontas	0.70	70.0	0.62	62.0
75% E. Ky. C 25% Pocahontas	0.84	69.8	0.75	62.3
50% E. Ky. C 25% Ill. No. 5 25% Pocahontas	0.99	68.7	0.81	56.2
50% E. Ky. C 25% Ill. No. 6 25% Pocahontas	0.86	68.0	0.73	57.7
75% Eagle 25% Pocahontas	0.68	76.2	0.58	65.0
50% Eagle 25% Ill. No. 5 25% Pocahontas	0.90	74.5	0.67	55.5
50% Eagle 25% Ill. No. 6 25% Pocahontas	0.79	73.3	0.66	61.2

Table 13. - Continued

Blend	Sulfur % in coal (as received)	Yield of dry coke (% of coal as rec'd)	Sulfur % in coke (dry)	Coal sulfur % remaining in coke
75% No. 2 Gas - Logan 25% Pocahontas	0.70	74.5	0.58	61.7
50% No. 2 Gas - Logan 25% Ill. No. 5 25% Pocahontas	0.86	72.4	0.74	62.2
50% No. 2 Gas - Logan 25% Ill. No. 6 25% Pocahontas	0.74	72.2	0.65	63.5
75% No. 2 Gas - Wyoming 25% Pocahontas	0.66	73.6	0.57	63.6
50% No. 2 Gas - Wyoming 25% Ill. No. 5 25% Pocahontas	0.89	72.4	0.67	54.5
50% No. 2 Gas - Wyoming 25% Ill. No. 6 25% Pocahontas	0.78	71.2	0.64	58.5
75% Clintwood 25% Pocahontas	0.81	72.6	0.77	69.0
50% Clintwood 25% Ill. No. 5 25% Pocahontas	0.96	71.2	0.86	63.8
50% Clintwood 25% Ill. No. 6 25% Pocahontas	0.88	71.0	0.77	62.1

safely, but recommend that only the plus 3/4-inch coal be used for coke. This size limitation is not a serious problem to the coal producers as the smaller sizes are in demand for stoker fuel and for industrial steam raising.

FREIGHT RATES

The southern Illinois coal fields are approximately 300 miles from the Chicago district, and only 100 miles from the Granite City - St. Louis area. Eastern Kentucky and West Virginia coal fields are about 600 miles from each of these consuming areas. Eastern coal comes to the Chicago market either by all-rail transportation or by a combination of rail and lake boat. Some coal is delivered to the St. Louis area by river barge, but the large tonnage arrives by rail.

Southern Illinois coal might be brought to either of these areas by river transportation; however, facilities have not been available for loading barges and delivering such water-borne coal directly to the point of consumption. Economics, therefore has favored all-rail transportation.

Freight rates from the southern Illinois and eastern coal fields are compared in table 14. The savings in transportation costs of southern Illinois coal compared with cost of shipping eastern coal are especially attractive in the Granite City and St. Louis areas, amounting to $2.09 and $2.67 per ton, respectively. A comparison of all-rail transportation costs to the Chicago district shows that Illinois coal has an advantage of $1.31; the Illinois rail rate compared with the eastern rail - lake boat rate shows an advantage of $0.95 per ton.

For some time prior to January 1956 the freight rate to Chicago on minus 2-inch southern Illinois coal was 65 cents per ton less than the regular rate shown in the table. The special rate has been discontinued and the same rate now applies to all sizes. There is a movement, however, to reduce the freight rate on all southern Illinois coal to the Chicago district, and this development should be watched.

Applying the rates shown in table 14, we have computed the freight charges to Chicago, Granite City, and St. Louis for each type of blend discussed in this report (table 15). We find that in Granite City the use of 75 percent Illinois coal in place of an equal amount of eastern coal has reduced the average freight charges on the blend $1.57 per ton. The reduction on the same coals delivered in St. Louis would amount to $2.01 per ton.

In Chicago the use of 25 percent Illinois coal in place of eastern coal would reduce freight charges on the blend 33 cents per ton if both Illinois and eastern coal were shipped by rail, or 24 cents if eastern coal arrived by lake boat. The use of 75 percent Illinois coal in the Chicago district in place of an equal amount of eastern high-volatile would reduce freight charges 98 cents or 71 cents per ton of blended coals, depending on how the eastern coal was shipped.

FREIGHT CHARGES PER TON OF COKE PRODUCED

Table 16 has been prepared to evaluate the freight charges per ton of furnace coke produced from each of the coal blends coked and studied for this report. Charges shown are computed from freight rates on coal and from the actual yields of furnace size coke (+1 inch) obtained in the experimental oven.

Table 14. - Freight Rates on Southern Illinois and Eastern Coals Compared (federal tax not included)

Bituminous coal, carloads	Freight rates (dollars per ton) Delivered in Chicago	Delivered in Granite City	Delivered in St. Louis
Southern Illinois	3.48	1.83	2.15
Eastern high-volatile:			
All-rail haul	4.79	3.92	4.82
Rail and lake boat (rail to lake port $3.30, transfer 18c, lake boat rate 95c)	4.43		
Eastern low-volatile:			
All-rail haul	4.99	4.07	4.97
Rail and lake boat (rail to lake port $3.47, transfer 18c, lake boat rate 95c)	4.60		

Table 15. - Computed Freight Charges on Coal Blends*

Coal blends	Freight charges (dollars per ton) Delivered in Chicago	Delivered in Granite City	Delivered in St. Louis
75% Illinois 25% Pocahontas			
All rail	3.86	2.39	2.85
Rail and lake boat	3.76		
75% Eastern high-volatile 25% Pocahontas			
All rail	4.84	3.96	4.86
Rail and lake boat	4.47		
50% Eastern high-volatile 25% Illinois 25% Pocahontas			
All rail	4.51	3.43	4.19
Rail and lake boat	4.23		

* Illinois coal shipped by rail. Eastern coal shipped by all-rail or by rail to Lake Erie and lake boat to Chicago.

Table 16. - Computed Freight Charges on Coal per Ton of Furnace Coke Produced*
(based on coke yields in pilot oven)

Run	Coal blend	Freight charges (per ton furnace coke) Produced in Chicago	Produced in Granite City	Produced in St. Louis
93-94	75% Ill. No. 5			
	25% Pocahontas			
	All rail	5.83	3.61	4.30
	Rail and lake boat	5.68		
84-85	75% Ill. No. 6			
	25% Pocahontas			
	All rail	6.14	3.80	4.53
	Rail and lake boat	5.98		
136	55% Ill. No. 6			
	20% Ill. No. 5			
	25% Pocahontas			
	All rail	5.98	3.70	4.42
	Rail and lake boat	5.83		
123	75% E. Ky. A			
	25% Pocahontas			
	All rail	7.26	5.94	7.29
	Rail and lake boat	6.70		
124	50% E. Ky. A			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.80	5.17	6.32
	Rail and lake boat	6.38		
126	50% E. Ky. A			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.81	5.18	6.33
	Rail and lake boat	6.39		
132	75% E. Ky. B			
	25% Pocahontas			
	All rail	7.23	5.92	7.26
	Rail and lake boat	6.68		
133	50% E. Ky. B			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.80	5.17	6.32
	Rail and lake boat	6.38		
131	50% E. Ky. B			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.87	5.23	6.39
	Rail and lake boat	6.45		

Table 16. - Continued

Run	Coal blend	Freight charges (per ton furnace coke) Produced in Chicago	Produced in Granite City	Produced in St. Louis
139-142	75% E. Ky. C			
	25% Pocahontas			
	All rail	7.40	6.05	7.43
	Rail and lake boat	6.83		
141	50% E. Ky. C			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.97	5.30	6.48
	Rail and lake boat	6.54		
140	50% E. Ky. C			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	7.08	5.38	6.58
	Rail and lake boat	6.64		
121	75% Eagle			
	25% Pocahontas			
	All rail	6.68	5.46	6.70
	Rail and lake boat	6.16		
122	50% Eagle			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.36	4.84	5.91
	Rail and lake boat	5.97		
125	50% Eagle			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.45	4.91	5.99
	Rail and lake boat	6.05		
158	75% No. 2 Gas - Logan			
	25% Pocahontas			
	All rail	6.94	5.68	6.97
	Rail and lake boat	6.41		
162	50% No. 2 Gas - Logan			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.67	5.07	6.20
	Rail and lake boat	6.26		
159	50% No. 2 Gas - Logan			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.67	5.07	6.20
	Rail and lake boat	6.26		

Table 16. - Continued

Run	Coal blend	Freight charges (per ton furnace coke) Produced in Chicago	Produced in Granite City	Produced in St. Louis
143	75% No. 2 Gas - Wyoming			
	25% Pocahontas			
	All rail	6.95	5.69	6.98
	Rail and lake boat	6.42		
145	50% No. 2 Gas - Wyoming			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.63	5.04	6.16
	Rail and lake boat	6.22		
146	50% No. 2 Gas - Wyoming			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.67	5.07	6.20
	Rail and lake boat	6.26		
163	75% Clintwood			
	25% Pocahontas			
	All rail	7.04	5.76	7.07
	Rail and lake boat	6.51		
165	50% Clintwood			
	25% Ill. No. 5			
	25% Pocahontas			
	All rail	6.70	5.10	6.23
	Rail and lake boat	6.28		
166	50% Clintwood			
	25% Ill. No. 6			
	25% Pocahontas			
	All rail	6.69	5.09	6.22
	Rail and lake boat	6.28		

* Illinois coal shipped by rail. Eastern coal shipped by all-rail or by rail to Lake Erie and lake boat to Chicago.

Coke yields are computed as the percentage of bone-dry coke produced per ton of moist coal charged to the oven. The freight charges are computed on each coke as it would be produced in Chicago, Granite City, or St. Louis.

Examination of table 16 shows that the freight saving per ton of coke made in Granite City is $2.24 as compared with the 75 percent eastern Kentucky A blend, or $1.98 as compared with the similar blend of No. 2 Gas seam from Logan County. Equivalent savings of $2.87 and $2.55 would be made in St. Louis.

In Chicago the use of 25 percent of Illinois No. 5 in place of the same amount of eastern Kentucky A would result in a freight saving of 46 cents per ton of coke if all eastern coal were delivered by rail, or of 32 cents if eastern coals were received by lake boat. The use of 75 percent of Illinois coals in the Chicago area in the proportions used at Granite City would result in a freight saving over the eastern Kentucky A coal of either $1.28 or 87 cents per ton of coke, depending on the means of transportation of the eastern coals. Freight savings on coke from Illinois blends compared with any combination of coals tested may be computed from the table.

While comparing coal and coke costs we wish to point out that Illinois coals normally are available at a lower mine price than are many of the eastern coking coals. Mining conditions in the Illinois field which favor lower costs of production make this possible. Savings in freight, therefore, normally represent only a portion of the actual reduction in delivered cost of the coals, or of the cokes made from them.

SUMMARY AND CONCLUSIONS

Pilot-plant tests on blends of Illinois and eastern coking coals used in the midwestern area, and observations on coal and coke characteristics and costs, have led to the following conclusions:

1. Illinois coals exert a relatively low expansion pressure on coke-oven walls. They may be used in blends to reduce the wall pressure exerted by more strongly expanding eastern coals. Eastern blends that by themselves exert low expansion pressures are not affected appreciably by the inclusion of Illinois coals.

2. Illinois coals tend to increase the strength of the cokes made with eastern Kentucky coals, and to have little effect on the strength of cokes made from the higher rank coals tested from West Virginia or Virginia.

3. The apparent gravity of coke is reduced consistently by Illinois coals. No. 6 coal has a greater effect than No. 5.

4. Coke size is not affected appreciably by addition of Illinois coals, except that the percentage of coke fines generally is reduced.

5. Coke yield is lowered consistently by Illinois coals because of their higher percentage of moisture, and, in some cases, their higher content of volatile matter.

6. Illinois coals are higher in sulfur than the eastern coals tested; however, they lose a greater percentage of their sulfur during carbonization than do most of these coals from the East. In only two cases was the percentage of sulfur in the coke increased more than 0.1 percent by the addition of 25 percent Illinois coal to the eastern blend.

7. Illinois coals are produced from thick, easily mined seams that are uni-

form in composition over a large area. They are washed and sized by modern equipment. Coal fines are not used for coke, and the prepared double-screened sizes are free-flowing from hopper cars and give little difficulty in freezing weather. They generally can be purchased more cheaply than many of the eastern coals because of favorable mining costs.

8. Freight rates on Illinois coals to the Chicago and St. Louis areas are lower than those on eastern coals, and the freight charges per ton of furnace coke produced in these areas are reduced when Illinois coals are used.

REFERENCES

Jackman, H. W., et al., 1955a, Coke oven to measure expansion pressure - modified Illinois oven: Illinois Geol. Survey Reprint Series 1955E.

Jackman, H. W., et al., 1955b, Comparison of mine sizes of southern Illinois coals for use in metallurgical coke: Illinois Geol. Survey Circ. 205.

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APPENDIX

ANALYSES OF COALS AND COKES, AND OTHER PERTINENT DATA

Table A. - Analytical Data for Experimental Coke Runs Shown in Table 3

Run		M.	Moisture-free basis				F.S.I.
			V.M.	F.C.	Ash	Sulfur	
93E-94E	75% Ill. No. 5						
	25% Pocahontas						
	Coal blend	4.5	31.7	61.5	6.8	1.21	6
	Coke		0.9	89.6	9.5	0.94	
84E-85E	75% Ill. No. 6						
	25% Pocahontas						
	Coal blend	6.5	32.7	60.0	7.3	1.12	5
	Coke		0.9	88.4	10.7	0.83	
136E	55% Ill. No. 6						
	20% Ill. No. 5						
	25% Pocahontas						
	Coal blend	6.2	32.0	60.5	7.5	1.06	5
	Coke		1.0	88.3	10.7	0.78	

Table B. - Analytical Data for Experimental Coke Runs Shown in Table 5

Run		M.	Moisture-free basis				F.S.I.
			V.M.	F.C.	Ash	Sulfur	
123E	75% E. Ky. A						
	25% Pocahontas						
	Coal blend	2.1	32.3	60.2	7.5	0.73	6½
	Coke		0.9	88.8	10.3	0.65	
124E	50% E. Ky. A						
	25% Ill. No. 5						
	25% Pocahontas						
	Coal blend	2.8	32.3	60.5	7.2	0.88	6
	Coke		1.0	88.7	10.3	0.73	
126E	50% E. Ky. A						
	25% Ill. No. 6						
	25% Pocahontas						
	Coal blend	3.6	32.1	60.6	7.3	0.84	4½
	Coke		0.8	89.0	10.2	0.68	

Table C. - Analytical Data for Experimental Coke Runs Shown in Table 6

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
132E	75% E. Ky. B 25% Pocahontas						
	Coal blend	1.9	33.3	62.2	4.5	0.58	6½
	Coke		0.8	92.3	6.9	0.53	
133E	50% E. Ky. B 25% Ill. No. 5 25% Pocahontas						
	Coal blend	3.2	33.0	61.7	5.3	0.80	6
	Coke		0.8	91.4	7.8	0.66	
131E	50% E. Ky. B 25% Ill. No. 6 25% Pocahontas						
	Coal blend	3.3	32.8	61.5	5.7	0.72	4½
	Coke		1.0	90.8	8.2	0.62	

Table D. - Analytical Data for Experimental Runs Shown in Table 7

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
139E-142E	75% E. Ky. C 25% Pocahontas						
	Coal blend	2.5	32.8	62.2	5.0	0.86	5
	Coke		1.2	91.3	7.5	0.75	
141E	50% E. Ky. C 25% Ill. No. 5 25% Pocahontas						
	Coal blend	3.3	32.2	61.9	5.9	1.03	4½
	Coke		0.9	90.4	8.7	0.81	
140E	50% E. Ky. C 25% Ill. No. 6 25% Pocahontas						
	Coal blend	3.8	32.9	61.2	5.9	0.90	4½
	Coke		0.9	90.4	8.7	0.73	

Table E. - Analytical Data for Experimental Runs Shown in Table 9

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
121E	75% Eagle - Raleigh						
	25% Pocahontas						
	Coal blend	0.9	26.6	67.3	6.1	0.68	8½
	Coke		0.8	91.0	8.2	0.58	
122E	50% Eagle - Raleigh						
	25% Ill. No. 5						
	25% Pocahontas						
	Coal blend	1.9	28.3	65.4	6.3	0.92	8½
	Coke		0.8	90.6	8.6	0.67	
125E	50% Eagle - Raleigh						
	25% Ill. No. 6						
	25% Pocahontas						
	Coal blend	3.1	28.1	65.2	6.7	0.82	8
	Coke		0.9	90.1	9.0	0.66	

Table F. - Analytical Data for Experimental Runs Shown in Table 10

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
158E	75% No. 2 Gas - Logan						
	25% Pocahontas						
	Coal blend	1.6	28.9	61.3	9.8	0.72	8½
	Coke		0.9	85.9	13.2	0.58	
162E	50% No. 2 Gas - Logan						
	25% Ill. No. 5						
	25% Pocahontas						
	Coal blend	3.0	30.2	60.6	9.2	0.89	8½
	Coke		1.0	86.6	12.4	0.74	
159E	50% No. 2 Gas - Logan						
	25% Ill. No. 6						
	25% Pocahontas						
	Coal blend	3.4	30.3	60.6	9.1	0.77	7½
	Coke		1.2	85.8	13.0	0.65	

Table G. - Analytical Data for Experimental Runs Shown in Table 11

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
143E	75% No. 2 Gas - Wyoming						
	25% Pocahontas						
	Coal blend	1.7	28.9	64.8	6.3	0.67	8
	Coke		0.9	90.5	8.6	0.57	
145E	50% No. 2 Gas - Wyoming						
	25% Ill. No. 5						
	25% Pocahontas						
	Coal blend	2.9	28.9	64.3	6.8	0.92	8
	Coke		0.6	90.7	8.7	0.67	
146E	50% No. 2 Gas - Wyoming						
	25% Ill. No. 6						
	25% Pocahontas						
	Coal blend	4.0	29.7	63.3	7.0	0.81	8
	Coke		1.0	89.5	9.5	0.64	

Table H. - Analytical Data for Experimental Runs Shown in Table 12

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
163E	75% Clintwood - Dickenson						
	25% Pocahontas						
	Coal blend	1.9	29.4	65.2	5.4	0.83	8
	Coke		0.7	92.0	7.3	0.77	
165E	50% Clintwood - Dickenson						
	25% Ill. No. 5						
	25% Pocahontas						
	Coal blend	2.3	29.8	64.2	6.0	0.98	8½
	Coke		0.7	91.0	8.3	0.86	
166E	50% Clintwood - Dickenson						
	25% Ill. No. 6						
	25% Pocahontas						
	Coal blend	2.7	30.2	63.7	6.1	0.90	8
	Coke		1.3	90.1	8.6	0.77	

Table I. - Medium-volatile Pocahontas Coal
(for comparison with low-volatile Pocahontas, Table 3)
Analysis and Plastic Properties

Analysis

	Moisture-free basis				
M.	V.M.	F.C.	Ash	Sulfur	F.S.I.
1.3	22.1	72.1	5.8	0.54	9+

Plastic Properties

Gieseler fluidity Dial div. per min.	at °C.	Plastic range (°C.) Softening	Solidification
464	474	413	513

Table J. - Blends of Medium-Volatile Pocahontas Coal and Illinois Coals
(Compare with Table A)

Run		M.	Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
130E-138E	75% Ill. No. 5						
	25% Med.-vol. Pocahontas						
	Coal blend	4.6	33.2	60.2	6.6	1.09	$7\frac{1}{2}$
	Coke		1.0	89.7	9.3	0.87	
129E	75% Ill. No. 6						
	25% Med.-vol. Pocahontas						
	Coal blend	6.5	34.4	58.2	7.4	1.04	7
	Coke		2.2	87.3	10.5	0.82	
127E	55% Ill. No. 6						
	20% Ill. No. 5						
	25% Med.-vol. Pocahontas						
	Coal blend	6.0	33.8	59.1	7.1	1.08	7
	Coke		1.2	88.7	10.1	0.88	

Table K. - Coking Tests on Medium-Volatile Pocahontas and Illinois Coal Blends (compare with Table 3)

	75% Ill. No. 5 25% Med.-Vol. Runs 130E-138E	75% Ill. No. 6 25% Med.-Vol. Run 129E	55% Ill. No. 6 20% Ill. No. 5 25% Med.-vol. Run 127E
Expansion pressure			
Lbs. per sq. in.	0.75	0.97	0.83
Bulk density (lbs. per cu. ft.)	51.3	51.1	51.5
Coke physical properties			
Tumbler test			
Stability	57.4	57.0	55.2
Hardness	69.6	68.3	68.9
Shatter test			
+2"	72.0	68.5	69.8
+1½"	91.1	90.5	90.8
+1"	96.9	96.5	96.7
Coke sizing			
+4"	1.8	2.7	2.4
4" x 3"	17.5	25.2	23.9
3" x 2"	43.9	44.4	47.5
2" x 1"	31.6	21.8	20.2
1" x ½"	1.5	1.8	2.4
-½"	3.7	4.1	3.6
Av. size (in.)	2.29	2.46	2.46
Apparent gravity	0.83	0.93	0.82
Coke yields (% of coal as charged)			
Total	68.1	66.1	66.4
Furnace (+1")	64.6	62.2	62.4
Nut and pea (1" x ½")	1.2	1.2	1.6
Breeze (-½")	2.5	2.7	2.4
Operating data			
Pulverization (-1/8")	79.0	79.3	79.4
Flue temp. (°F.)	1950	1950	1950
Coking time (hr.)	16:30	16:30	16:30

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