STATE OF ILLINOIS
OTTO KERNER, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
WILLIAM SYLVESTER WHITE, *Director*

USE OF ILLINOIS COAL FINES IN PRODUCTION OF METALLURGICAL COKE

H. W. Jackman
R. J. Helfinstine

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

CIRCULAR 317 1961

USE OF ILLINOIS COAL FINES IN PRODUCTION OF METALLURGICAL COKE

H. W. Jackman and R. J. Helfinstine

ABSTRACT

Changing market conditions and new mining methods have prompted investigation of the use of Illinois coals in a wide range of mine sizes, including the fines, for making coke. Utilization of all, or a very large percentage of, mine output for coke should have economic advantages for both coal and coke producers.

Previously only coal in mine sizes larger than three quarters of an inch has been recommended and used by the coke industry. To determine the effect of wider size ranges, certain mine sizes, including 2" x 10 mesh and 3" x 0, have been studied from the standpoint of their preparation, their coking properties in blends, and their weathering characteristics.

Tests have indicated that coals in these size ranges, from Illinois mines supplying coal to the coke industry, may be prepared to a satisfactory analysis, and that their blends produce cokes with physical properties comparable to those made with only the larger coal sizes.

Weathering tests indicate that coals in the 2" x 10 mesh and 3" x 0 sizes may be stockpiled throughout the summer months and subsequently coked in blends with fluid medium-volatile coals without significant deterioration in physical properties of the cokes produced.

We have concluded that the coals of southern Illinois used by the coke industry may be supplied in a wide range of sizes, including the fines, and that when the coal is properly prepared, the size range to be used may be determined primarily by relative coal costs.

INTRODUCTION

Annual steel ingot capacity in the United States in January 1961 was approximately 150 million tons. Of this, the Chicago and St. Louis areas have capacity to produce 33 million tons, or about 22 percent of the total. This midwestern area is exceeded in ingot capacity only by the Pittsburgh-Youngstown district, all of which lies in or near the major bituminous coal fields of the Appalachian area. Steel plants in this eastern district can obtain best-quality coking coals, therefore, at relatively low freight rates either by river barge or short rail haul.

The Chicago and St. Louis areas also use large tonnages of eastern coking coals, all of which must be transported from Pennsylvania, the Virginias, or eastern Kentucky, distances of 500 miles or more. Most economical transportation to Chicago is by rail from the mines to a Lake Erie port, and from there by lake boat over the circuitous route of Lake Huron, the Straits of Mackinaw, and Lake Michigan.

Large tonnages also are delivered to Chicago and St. Louis directly from eastern mines by all-rail transportation. These eastern coals deliver in midwestern steel plants at a considerably higher cost, therefore, than they do in the Pittsburgh and other eastern plants.

BACKGROUND STUDIES

Early Coking Experiments at the Illinois State Geological Survey

During World War II the Illinois State Geological Survey started research to determine whether coals mined in the area of low-sulfur coal in southern Illinois could replace a portion of the eastern coal used in midwestern steel mills. The immediate goal of the project was to relieve the congested wartime rail traffic by obtaining coal from closer mines. In addition, the Survey hoped to show that Illinois coals could be used to economic advantage in the Chicago and St. Louis area steel mills, thereby developing a new market for Illinois coals.

The Geological Survey first designed and built an experimental coke oven holding 500 pounds of coal in which blends of Illinois and eastern coals could be coked and evaluated (Reed et al., 1945, 1947). The oven was later replaced by one of 700-pounds capacity and full commercial oven width (Jackman et al., 1955). Both ovens were operated at temperatures and coking rates similar to those used with commercial ovens, and they produced coke that closely duplicated the commercial product. With these tools we were able to demonstrate that Illinois coals could be used for coking, and a market for more than three-quarters of a million tons of Illinois coal a year was developed. This market has continued, and, as there is a potential market for several times this tonnage, the Survey has continued its research to determine and demonstrate how the coals of Illinois can be used to the greatest advantage by the metallurgical coke industry.

Illinois Coals Used for Coke

Coal that has been used commercially for metallurgical coke is mined from No. 5 and No. 6 Coals in southern Illinois. They are high-volatile, bituminous B-rank coals, according to ASTM classification; they are currently mined from beds 5 to 11 feet thick, are produced from underground mines, and are mechanically cleaned to acceptable ash and sulfur values.

Illinois coking coals develop less plasticity than do most of the higher rank eastern high-volatile coals. Like all high-volatile coals, they must be blended with low- or medium-volatile coals to produce coke of metallurgical quality. By use of blending procedures developed in the Survey laboratories and in commercial plants where these coals are used, cokes with excellent physical properties are being produced.

Mine Sizes Recommended

Until recently the Geological Survey has recommended the use of double-screened Illinois coal for coke, with a bottom size of about three-quarters of an inch. Coal fines were eliminated for two reasons: first, the small sizes have greater surface area that is susceptible to oxidation, and, second, the extreme fines contain the highest percentage of fusain, a noncoking ingredient found in varying proportions in all coals.

In the past this size limitation inflicted no great hardship on Illinois coal producers because the domestic stoker and power plant markets absorbed the smaller coals. However, in order to increase the tonnage available for the coke industry, and to compensate for the decreasing market for domestic stoker coal and for the smaller coal produced by modern mechanical mining, we have investigated the use of a wide range of sizes, including the fines.

Acknowledgments

We express appreciation for the invaluable help given to us throughout the entire coking project by the coal industry and by the steel and coke producers in the Chicago and St. Louis areas. We especially thank the Granite City Steel Company, Inland Steel Company, Interlake Iron Corporation, Republic Steel Company, the Bell and Zoller Coal Company, Freeman Coal Mining Corporation, Old Ben Coal Company, and Sahara Coal Company, all of which have furnished coals used in this study.

PROCEDURE

To evaluate adequately coal with smaller bottom size than that previously used, three factors were investigated — coal preparation, effect of fines on coke quality, and effect of fines on weathering characteristics of the coal. Results of each study are given below.

Coal Preparation

Adequate coal preparation over the entire size range is most important if the smaller sized coals are to be used for coke, and if Illinois coals are to continue to compete with many of the eastern coking coals. Various cleaning methods and types of equipment are used by the Illinois mines capable of supplying coal to the metallurgical coke industry. Coal may be all washed in pulsating jigs or heavy-medium washers, or the small sizes may be removed first and cleaned separately. In certain mines a portion of the jig-washed coal is cleaned further for metallurgical coke by heavy-medium washing.

Coal ash may be reduced to any reasonable percentage, regardless of size composition, although there is an obvious relation between ash reduction and preparation costs. Unlike ash, sulfur cannot be reduced appreciably by present preparation methods.

In this report we have not included analyses of individual coals as it would be difficult to do so without disclosing the identity of the mines of origin. Many of our samples were taken during the development of preparation plants, or before sufficient cleaning equipment was installed. It has been demonstrated, however, that the Illinois coals, including the fines, can be cleaned to an analysis approximately the same as that of the double-screened coal furnished to the steel industry in the past.

Effect of Fines on Coke Quality

When the metallurgical coke project started at the Survey, and for some years afterwards, continuous mining machines were in their initial development, and primarily the older types of mechanical mining were used in the Illinois area. Under these mining conditions the fusain, much of which occurs in soft lenses,

found its way into the fines, especially into the minus 48-mesh portion, and it was thought undesirable to include fines in the coal supplied for coke.

The expanded use of continuous miners produced a larger percentage of small-size coal and it became increasingly desirable to include the smaller sizes in the coal used for carbonization. We therefore tested samples from Illinois mines in various size ranges, both with and without the fines. These coals were coked in blends and the cokes compared. Results of these tests, shown in part in table 1, indicate that reducing the bottom size of Illinois coals has little effect on physical properties of cokes made from their blends. This was shown to be true for both Illinois No. 6 and No. 5 Coals. Following our initial tests, coals that contain the finer sizes have been coked extensively in commercial operations producing blast furnace coke.

TABLE 1 - COMPARISON OF MINE SIZES OF ILLINOIS COALS IN TYPICAL BLENDS

	Tumbler test		Coke yields (%)	
	Stability	Hardness	Furnace (+1")	Screenings (-1")
Blend - 55% Illinois No. 6 (Mine A), 20% Illinois No. 5, 25% Pocahontas				
Mine size Illinois No. 6				
3" x 2"	53.8	64.2	64.2	5.2
2" x 10 mesh	52.7	65.6	64.7	4.5
Blend - 70% Illinois No. 6 (Mine A), 30% Medium-volatile				
Mine size Illinois No. 6				
2" x 3/4"	58.6	67.9	64.6	4.4
2" x 10 mesh	56.3	65.8	64.8	4.2
Blend - 70% Illinois No. 6 (Mine B), 30% Medium-volatile				
Mine size Illinois No. 6				
3" x 1"	56.1	67.3	66.5	3.9
3" x 1/4"	56.3	68.1	66.4	3.8
3" x 0	57.4	67.6	65.7	3.9
Blend - 75% Illinois No. 5, 25% Pocahontas				
Mine size Illinois No. 5				
3" x 1½"	55.4	66.5	67.4	4.3
3" x 28 mesh	55.4	65.6	66.3	4.3
1" x 28 mesh	54.7	66.1	66.3	4.9
Blend - 55% Illinois No. 6, 20% Illinois No. 5, 25% Pocahontas				
Mine size Illinois coals				
No. 6 - 3" x 2" / No. 5 - 3" x 2"	55.5	65.2	65.0	5.4
No. 6 - 2" x 10 mesh / No. 5 - 3" x 28 mesh	56.7	64.8	65.3	4.4

Effect of Fines on Weathering Characteristics

After it had been demonstrated that freshly mined Illinois coal including the small sizes could be used for coke when properly prepared and blended, it became necessary to determine whether such coals could be stockpiled and weathered without affecting the properties of coke subsequently made from their blends. Previous weathering tests on 3" x 1" coal had shown that Illinois coal of this larger size should not be stockpiled in summer weather for more than thirty days when it was to be blended in large percentages with low-volatile Pocahontas Coal, but that it could be stockpiled all summer when the blending coal was one of the more fluid medium-volatile coals (Jackman et al., 1957, 1959). Such coals of 21 to 25 percent volatile matter supplement the low fluidity of Illinois coal, even after weathering. Cokes made from their blends have normal physical properties unaffected by the weathered coal.

Small-size coal, because of its greater surface area, can be expected to weather in uncompacted piles more rapidly than coal of larger size. Weathering tests were needed, therefore, for the 2" x 10-mesh and 3" x 0 coals. Three storage piles were established where they could be sampled as required. About 300 tons of 2" x 10-mesh coal from mine A were stocked in Chicago, and two 150-ton piles of 3" x 0 coal were stocked at mine B in southern Illinois. One of the piles at mine B was compacted to 65 pounds per cubic foot, and the other was uncompacted. All piles were sampled at approximately monthly intervals, and the coals were coked in six series of blends. Five blends contained medium-volatile coal, and the sixth contained low-volatile Pocahontas. Illinois coal in the six blends ranged from 25 to 70 percent of the total. All were coked in the movable-wall pilot oven of 700 pounds coal capacity by methods previously described (Jackman et al., 1955, 1959). Any or all of these blends could have commercial possibilities.

For comparison a fourth storage pile was made of the larger 3" x 1" coal, and this was compared with the 3" x 0 coal in one series of tests.

RESULTS OF WEATHERING TESTS

Weathering tests were made throughout the period from June to November so as to include the warmest months when oxidation has been shown to be most rapid. These tests indicated that weathering the Illinois coals had little if any detrimental effect on cokes made from their blends with fluid coals. The Illinois coals weathered as expected. Gieseler fluidity of the coals in all three piles dropped from more than 30 to about 3 dial divisions per minute in four months. The rate and amount of oxidation seemed to be independent of the mine of origin, the amount of compaction, or the bottom size of the fine coal.

The 3" x 1" coal oxidized also, as was expected, but not quite as rapidly as the smaller sizes. This coal required about six months for the fluidity to drop to 3 dial divisions.

Plasticity and swelling data on the Illinois coals are shown in table 2, and on their blends in table 3. Each blend studied is considered briefly. Details of coking test results are shown in tables A through G in the appendix, and pertinent results indicating possible deterioration due to weathering are plotted in figures 1 to 3.

TABLE 2 - PLASTIC AND SWELLING PROPERTIES OF ILLINOIS COALS DURING STORAGE

Days since stockpiling Illinois coal	Gieseler fluidity: Max. dial div. per min.	Free-swelling index
Ill. No. 6 (2" x 10 mesh), Mine A		
3	44	3½
40	26	4½
64	8	4½
113	3	4
163	7	4
Ill. No. 6 (3" x 0, uncompacted), Mine B		
2	34	4
38	24	4½
64	14	3½
112	-	4
157	5	4
Ill. No. 6 (3" x 0, compacted), Mine B		
2	34	4
44	22	3½
66	13	4½
119	3	5
163	11	4½
Ill. No. 6 (3" x 1"), Mine B		
1	32	3
38	16	4
65	25	4
90	14	4
133	7	4
181	3	4½

TABLE 3 - PLASTIC AND SWELLING PROPERTIES OF COAL BLENDS

Days since stockpiling Illinois coal	Gieseler fluidity: Max. dial div. per min.	Free-swelling index
25% Ill. No. 6 (2" x 10 mesh), Mine A 25% Elkhorn 50% Medium-volatile		
3	450	8
40	167	7
64	133	7½
113	35*	7
163	109	7
* Elkhorn coal had low fluidity also.		
70% Ill. No. 6 (2" x 10 mesh), Mine A 30% Medium-volatile		
24	37	6
44	14	5½
118	6	5½
176	7	6
70% Ill. No. 6 (3" x 0 uncompacted) Mine B 30% Medium-volatile		
2	29	6
38	15	6½
64	18	6
112	9	5½
157	9	6
70% Ill. No. 6 (3" x 0 compacted), Mine B 30% Medium-volatile		
2	34	4
44	22	3½
66	13	4½
119	3	5
163	11	4½
30% Ill. No. 6 (3" x 0 compacted), Mine B 30% Eagle 15% Elkhorn 25% Pocahontas (low-vol.)		
16	40	5
42	25	5
70	106	5
114	73	6
161	41	4½

Blend 1: 25% Illinois No. 6 Coal (2" x 10 mesh), Mine A
25% Elkhorn
50% Medium-volatile

Blend 1, which contained 25 percent Illinois No. 6 Coal (2" x 10 mesh) from Mine A along with Kentucky Elkhorn and medium-volatile coals, is one that has been used commercially with Illinois coal in this size range in the Chicago area. Five coking tests, made at intervals over 163 days, produced cokes all of which had essentially the same physical properties. Stability ranged from 58.5 to 62.1, and hardness from 68.4 to 70.9. Coke yields, including furnace, nut, and breeze sizes, were almost identical at the beginning and end of the storage

period, and the expansion pressure exerted on oven walls showed no significant trend. From all appearances and tests, any one of the cokes would have functioned well for blast furnace fuel. Note in table A of the appendix that a little weathering seemed to improve the tumbler indices, and that these values at the end of the weathering period were slightly higher than with all fresh coals.

Blend 2: 70% Illinois No. 6 Coal (2" x 10 mesh), Mine A
30% Medium-volatile

Blend 2, which contained 70 percent of the same 2" x 10-mesh Illinois No. 6 Coal blended with 30 percent medium-volatile coal, represents a much more drastic test for the effect of weathering than does blend 1, owing to the high percentage of Illinois coal. Four tests extending over a period of 176 days storage time indicate, however, that coke strength was not affected adversely by weathering. Stability and hardness indices actually increased about four points during the period (table B, appendix). The coke became slightly smaller, and the yield of breeze increased 0.5 percent. Otherwise this blend showed no significant change in coking properties due to weathering the 2" x 10-mesh coal.

Blend 3: 70% Illinois No. 6 Coal (3" x 0, uncompacted), Mine B
30% Medium-volatile

Blend 3 is very similar to blend 2 except that it contains 70 percent of the Illinois No. 6 Coal (3" x 0) from the uncompacted pile that was stockpiled at mine B. Tests covered a period of 157 days. Here also the coke retained its strength with no loss in tumbler indices. Coke sizing was comparable throughout the test period except for an increase in breeze yield of a little less than one percent (table C, appendix). The effects of weathering this 3" x 0 coal from mine B were essentially the same as those of the 2" x 10-mesh coal from mine A.

Blend 4: 70% Illinois No. 6 Coal (3" x 0, compacted), Mine B
30% Medium-volatile

Blend 4, which contained 70 percent Illinois No. 6 Coal (3" x 0, compacted) from mine B, produced coke almost identically like that from blend 3, which contained the uncompacted coal (table D, appendix). Tumbler indices actually increased slightly as weathering proceeded, and the breeze yield again increased less than one percent of the weight of coal carbonized. Coking results from the compacted and uncompacted coals are so nearly identical that there appears to be nothing gained by compacting this coal in stock.

Blend 5: 30% Illinois No. 6 Coal (3" x 0, compacted), Mine B
30% Eagle
15% Elkhorn
25% Pocahontas

Blend 5 differed from the other blends in that low-volatile Pocahontas Coal was used instead of medium-volatile coal. Fluidity was supplied by the West Virginia Eagle and eastern Kentucky Elkhorn Coals. Weathering the compacted 3" x 0 Illinois coal over a 161-day period had little effect on coke properties (table E, appendix). Tumbler indices actually decreased one to two points and the yield of breeze increased 0.6 percent. Otherwise coke size and other physical properties were not affected by stockpiling the Illinois coal.

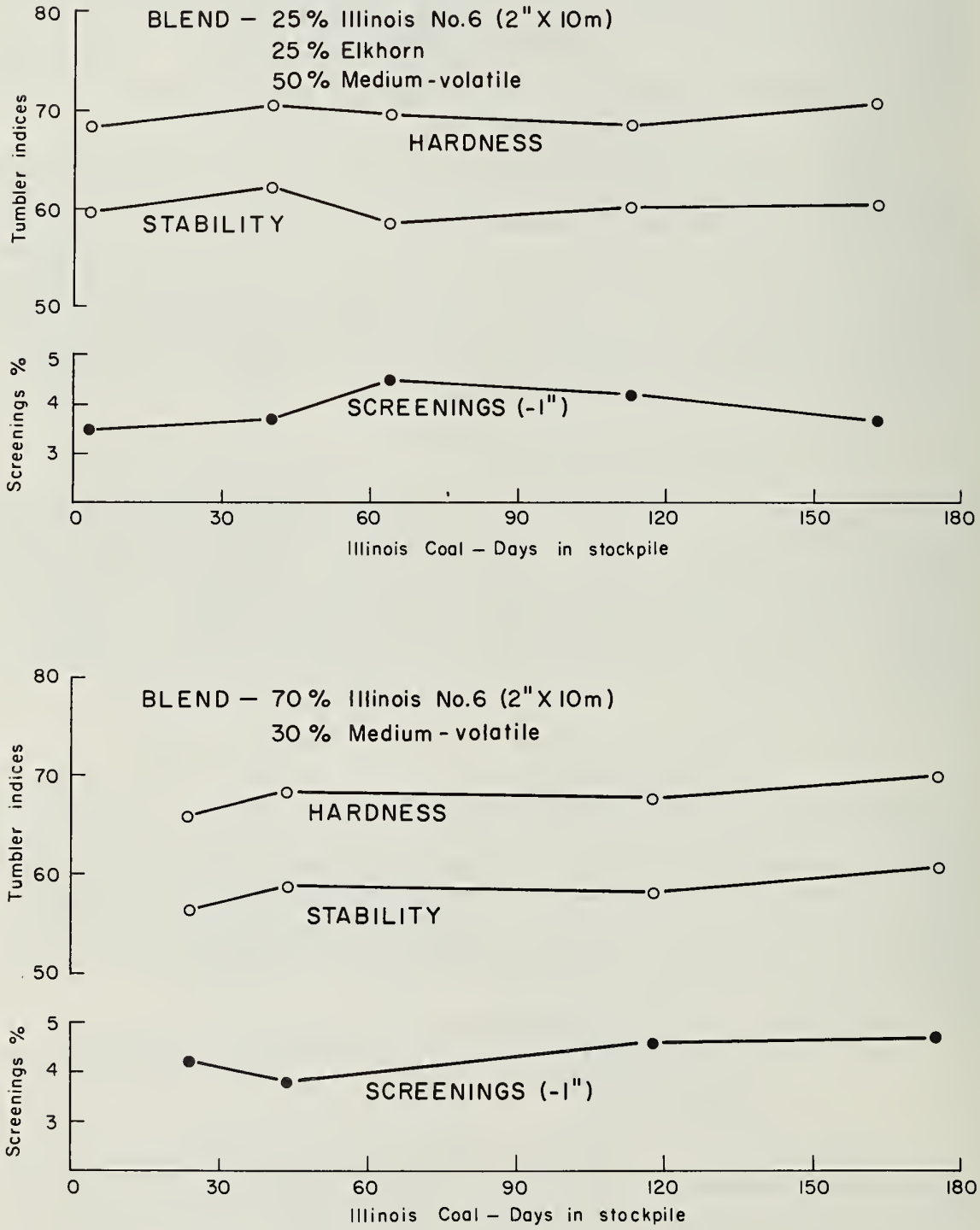

Fig. 1 - Effect of weathering Illinois No. 6 Coal (2" x 10 mesh).

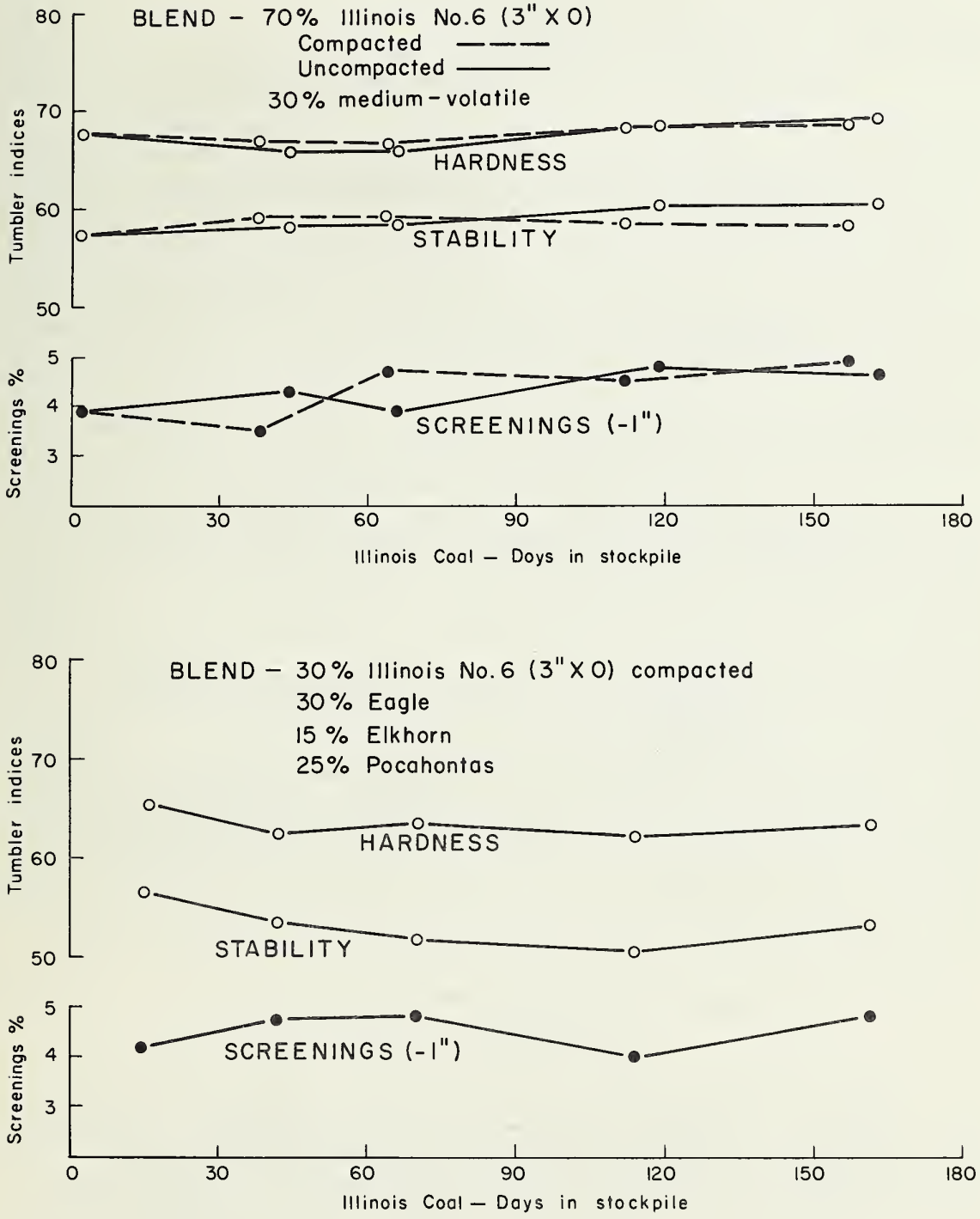

Fig. 2 - Effect of weathering Illinois No. 6 Coal (3" x 0).

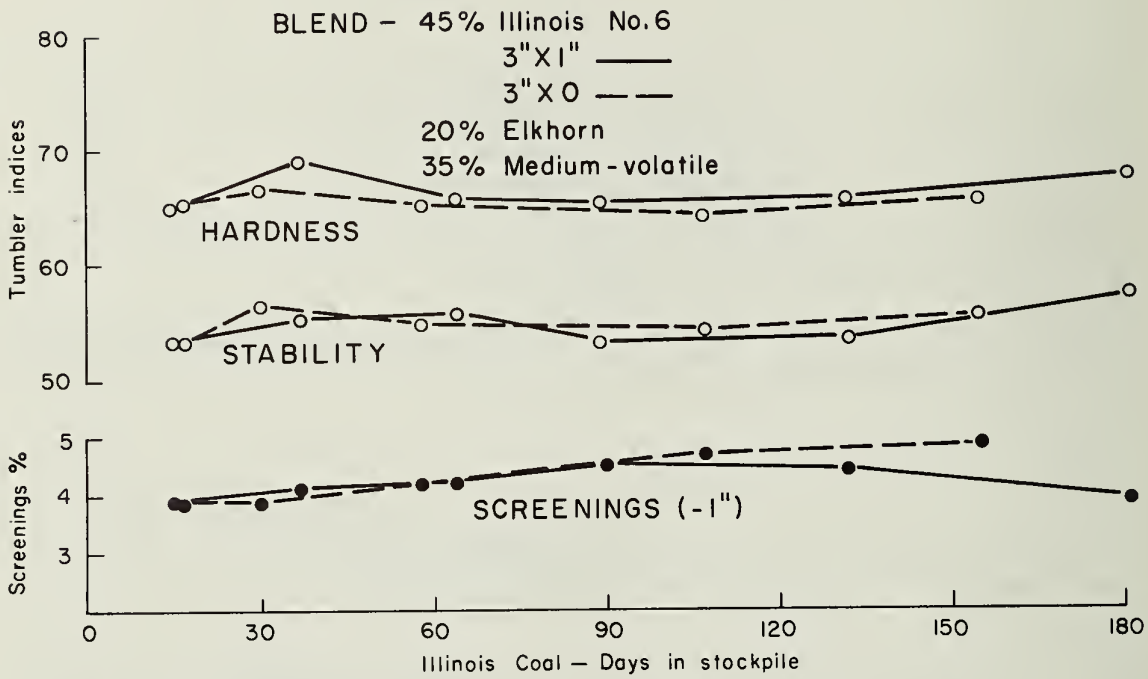

Fig. 3 - Comparison of weathered coals in two sizes, 3" by 1" and 3" by 0.

Blend 6: 45% Illinois No. 6 Coal (3" x 0, uncompacted), Mine B
20% Elkhorn
35% Medium-volatile

In this blend 45 percent of the 3" x 0 uncompacted Illinois No. 6 Coal was blended with Elkhorn and medium-volatile coals, both having high fluidity. The Illinois coal remained in stock for 155 days, and here again, owing to fluidity of the other coals, the coke properties did not deteriorate (table F appendix). Tumbler stability increased from 53.4 to 55.7, and hardness remained practically unchanged between 65 and 66. The yield of breeze increased 1.2 percent. Otherwise there was no apparent change in coke properties throughout the weathering period.

Blend 7: 45% Illinois No. 6 Coal (3" x 1")
20% Elkhorn
35% Medium-volatile

Blend 7 was tested only to compare the 3" x 1" Illinois coal with the 3" x 0 size. Otherwise it is identical with the previous blend described. Coking results were very similar, and tumbler indices again increased (table G, appendix). Breeze yield increased slightly during the first 90 days of storage, but decreased again to nearly the original value. Examination of coking results from this and the previous series of tests in which weathered 3" x 1" and 3" x 0 coals are compared indicates that the double-screened coal has no advantage except probably less tendency toward an increased breeze yield as weathering progresses.

SUMMARY AND CONCLUSIONS

Because of changing market conditions and mining methods it now seems desirable to utilize the full size range of Illinois coals for metallurgical coke. Heretofore, no coal smaller than three-quarters of an inch has been recommended or used. To determine the effect of widening the size range to include the smaller sizes we have evaluated coking characteristics of Illinois coals in the 2" x 10-mesh and 3" x 0 size ranges.

The percentage of ash in Illinois coals supplied to the steel industry is an economic problem to be resolved by mutual agreement of the coal producers and consumers. Ash in the coal can be reduced by proper cleaning to any reasonable percentage, regardless of the size of the coal. Obviously, there is a relation between ash reduction and preparation costs. Analytical tests on samples taken at mines and at coke plants, and conferences with coal producers, indicate that these coals can be furnished to the steel industry at a mutually agreeable ash content, similar to that of the double-screened coals furnished in the past.

No appreciable difference has been noted in the percentage of sulfur in the various size fractions of coal from a given mine. Unlike ash, sulfur cannot be reduced appreciably by present preparation methods.

Coking tests and commercial use of Illinois full-size-range coals indicate that they may be used in blends without sacrifice in coke quality provided care is taken to avoid size segregation in handling and in blending.

Weathering tests on 2" x 10-mesh and 3" x 0 mine sizes have shown that these coals may be stocked throughout the summer months and blended subsequently with fluid medium-volatile coals. Blends containing 25 to 70 percent of the stockpiled coals showed no significant changes in coke physical properties throughout a five-month period except for an increase of around one percent or less in the yield of coke breeze.

We have concluded therefore that the size range of Illinois coal previously recommended for coke may be extended to include properly prepared sizes down to 10-mesh or 0, and that these coals may be stockpiled throughout the summer months if they are to be blended subsequently with fluid coals such as the medium-volatile coals used in these tests. Assuming proper coal preparation, it appears therefore that choice of the bottom size of Illinois coals for coke production may be determined primarily by relative coal costs rather than by considerations of coke quality.

REFERENCES

Jackman, H. W., Eissler, R. L., Helfinstine, R. J., 1959, Stockpiling Illinois coal for coke: Illinois Geol. Survey Circ. 274.

Jackman, H. W., Eissler, R. L., Reed, F. H., 1957, Weathering of Illinois coals during storage: Illinois Geol. Survey Circ. 227.

Jackman, H. W., Helfinstine, R. J., Eissler, R. L., and Reed, F. H., 1955, Coke oven to measure expansion pressure - Modified Illinois oven: Blast Furnace Coke Oven and Raw Materials Conf. Proc., Am. Inst. Min. Met. Eng., v.14; Illinois Geol. Survey Reprint Series 1955E.

Reed, F. H., Jackman, H. W., Rees, O. W., Yohe, G. R., Henline, P. W., 1947, Use of Illinois coal for production of metallurgical coke: Illinois Geol. Survey Bull. 71.

Reed, F. H., Jackman, H. W., Henline, P. W., 1945, Coke from Illinois coals. An experimental slot-type oven: Ind. Eng. Chem.,v.37, no. 6, p. 560-566; Illinois Geol. Survey Rept. Inv. 107.

Additional selected publications that report the results of Illinois State Geological Survey research on the use of Illinois coals in manufacture of metallurgical coke are listed below.

Petroleum coke in Illinois coal blends for blast furnace coke: Illinois Geol. Survey Circ. 305, 1960.

Coke from medium-volatile and Illinois coals: Illinois Geol. Survey Circ. 278, 1959.

Influence of coking time on expansion pressure and coke quality: Illinois Geol. Survey Circ. 246, 1958.

Coking coals of Illinois. Their use in blends for metallurgical coke: Illinois Geol. Survey Circ. 219, 1956.

Factors affecting coke size: Illinois Geol. Survey Circ. 213, 1956.

Comparison of mine sizes of southern Illinois coals for use in metallurgical coke: Illinois Geol. Survey Circ. 205, 1955.

Sizing studies on pilot-oven coke. Comparison with commercial coke size: Illinois Geol. Survey Circ. 202, 1955.

Char for metallurgical coke: Illinois Geol. Survey Rept. Inv. 187, 1955.

Some observations on the blending of coals for metallurgical coke: Blast Furnace and Steel Plant, v. 40, no. 3, March 1952, p. 305-311, 344: Illinois Geol. Survey Circ. 178, 1952.

The use of Illinois coal in the production of metallurgical coke: AIME Tech. Pub. No. 2491, Class F, Coal Technology, Nov. 1948.

APPENDIX

COKING TEST RESULTS

TABLE A - COKING TEST RESULTS FOR COAL BLEND 1

25% Illinois No. 6 (2" x 10 m), Mine A
25% Elkhorn
50% Medium-volatile

Date of test	Run 507E 3-3-60	Run 546E 7-18-60	Run 555E 8-11-60	Run 561E 9-29-60	Run 576E 11-18-60
Days since stockpiling Illinois coal	3	40	64	113	163
		Coke Physical Properties			
Tumbler test					
Stability	59.6	62.1	58.5	60.1	60.4
Hardness	68.4	70.5	69.6	68.9	70.9
Shatter test					
+2"	74.5	68.5	67.1	78.7	71.5
+1½"	94.5	91.4	89.6	93.0	90.2
Coke sizing					
+4"	2.8	0.4	1.8	2.3	2.6
4" x 3"	14.8	16.7	20.3	16.2	15.4
3" x 2"	51.4	49.8	42.7	46.4	47.0
2" x 1"	26.1	27.9	29.0	29.3	29.8
1" x ½"	1.6	1.6	2.0	1.7	1.7
-½"	3.3	3.6	4.2	4.1	3.5
Average size (in.)	2.34	2.28	2.32	2.29	2.30
Apparent gravity	0.84	0.86	0.85	0.84	0.87
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	71.8	72.1	72.0	71.9	72.2
Furnace (+1")	68.3	68.4	67.5	67.7	68.5
Nut (1" x ½")	1.1	1.1	1.4	1.2	1.2
Breeze (-½")	2.4	2.6	3.1	3.0	2.5
		Expansion Pressure			
Lbs. per sq. in.	1.1	1.0	0.7	0.7	1.3
Bulk density (lbs. per cu. ft.)	52.5	53.3	53.6	52.6	54.7
		Operating Data			
Pulverization (% -1/8")	84.0	77.8	79.4	83.8	82.9
Flue temp. (°F.)	1970	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30	16:30

TABLE B - COKING TEST RESULTS FOR COAL BLEND 2

70% Illinois No. 6 (2" x 10 m), Mine A
30% Medium-volatile

Date of test	Run 512E 3-24-60	Run 548E 7-22-60	Run 562E 10-4-60	Run 579E 12-1-60
Days since stockpiling Illinois coal	24	44	118	176
		Coke Physical Properties		
Tumbler test				
Stability	56.3	58.8	58.0	60.7
Hardness	65.8	68.3	67.6	69.8
Shatter test				
+2"	72.6	71.9	68.8	70.5
+1½"	90.3	91.4	89.6	88.6
Coke sizing				
+4"	3.0	1.4	3.5	1.1
4" x 3"	18.1	16.6	17.1	16.8
3" x 2"	48.8	49.8	44.9	46.2
2" x 1"	24.0	26.7	27.7	28.9
1" x ½"	2.2	1.8	1.7	2.2
-½"	3.9	3.7	5.1	4.8
Average size (in.)	2.37	2.31	2.32	2.25
Apparent gravity	0.79	0.82	0.80	0.80
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)		
Total	68.9	68.5	67.7	68.3
Furnace (+1")	64.7	64.7	63.1	63.5
Nut (1" x ½")	1.5	1.2	1.1	1.5
Breeze (-½")	2.7	2.6	3.5	3.2
		Expansion Pressure		
Lbs. per sq. in.	1.0	0.95	-	1.0
Bulk density (lbs. per cu. ft.)	52.4	53.5	53.9	53.9
		Operating Data		
Pulverization (% -1/8")	80.2	77.8	84.2	83.2
Flue temp. (°F.)	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30

TABLE C - COKING TEST RESULTS FOR COAL BLEND 3

70% Illinois No. 6 (3" x 0, uncompacted), Mine B
30% Medium-volatile

Date of test	Run 503E 2-19-60	Run 543E 7-8-60	Run 552E 8-3-60	Run 558E 9-20-60	Run 572E 11-4-60
Days since stockpiling Illinois coal	2	38	64	112	157
		Coke Physical Properties			
Tumbler test					
Stability	57.4	59.1	59.2	58.5	58.1
Hardness	67.6	66.8	66.6	68.1	68.5
Shatter test					
+2"	66.9	74.4	76.0	71.4	76.5
+1½"	92.4	92.1	91.5	88.8	90.4
Coke sizing					
+4"	1.2	3.6	3.2	2.3	2.1
4" x 3"	14.0	18.7	17.5	16.4	18.7
3" x 2"	49.8	48.8	48.1	44.7	47.4
2" x 1"	29.3	23.7	24.1	30.0	24.8
1" x ½"	2.0	1.8	2.1	2.0	2.3
-½"	3.7	3.4	5.0	4.6	4.7
Average size (in.)	2.25	2.41	2.35	2.27	2.34
Apparent gravity	0.815	0.78	0.78	0.81	0.805
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	69.6	68.5	68.7	69.2	69.9
Furnace (+1")	65.7	64.9	64.0	64.7	65.0
Nut (1" x ½")	1.3	1.3	1.4	1.3	1.6
Breeze (-½")	2.6	2.3	3.3	3.2	3.3
		Expansion Pressure			
Lbs. per sq. in.	1.1	0.7	-	0.7	1.4
Bulk density (lbs. per cu. ft.)	53.8	50.9	51.2	53.3	53.4
		Operating Data			
Pulverization (% -1/8")	83.9	83.2	83.1	80.1	83.6
Flue temp. (°F.)	1970	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30	16:30

TABLE D - COKING TEST RESULTS FOR COAL BLEND 4

70% Illinois No. 6 (3" x 0, compacted), Mine B
30% Medium-volatile

Date of test	Run 503E 2-19-60	Run 545E 7-14-60	Run 553E 8-5-60	Run 560E 9-27-60	Run 574E 11-10-60
Days since stockpiling Illinois coal	2	44	66	119	163
		Coke Physical Properties			
Tumbler test					
Stability	57.4	58.2	58.4	60.2	60.4
Hardness	67.6	65.8	65.9	68.5	69.2
Shatter test					
+2"	66.9	73.5	76.7	74.1	72.0
+1½"	92.4	92.3	93.9	90.4	89.8
Coke sizing					
+4"	1.2	1.2	2.5	2.2	1.1
4" x 3"	14.0	17.3	18.3	19.7	15.3
3" x 2"	49.8	51.2	50.6	47.3	49.2
2" x 1"	29.3	24.1	22.6	23.8	27.6
1" x ½"	2.0	1.8	1.7	1.9	2.0
-½"	3.7	4.4	4.3	5.1	4.8
Average size (in.)	2.25	2.32	2.38	2.35	2.26
Apparent gravity	0.815	0.78	0.77	0.80	0.82
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	69.6	68.3	67.7	69.0	69.4
Furnace (+1")	65.7	64.0	63.8	64.2	64.8
Nut (1" x ½")	1.3	1.3	1.0	1.3	1.3
Breeze (-½")	2.6	3.0	2.9	3.5	3.3
		Expansion Pressure			
Lbs. per sq. in.	1.1	0.8	0.8	0.7	1.3
Bulk density (lbs. per cu. ft.)	53.8	51.0	50.6	52.9	54.1
		Operating Data			
Pulverization (% -1/8")	83.9	83.4	83.5	82.2	85.0
Flue temp. (°F.)	1970	1970	1970	1970	1970
Coking time (hr.: min.)	16:30	16:30	16:30	16:30	16:30

TABLE E - COKING TEST RESULTS FOR COAL BLEND 5

30% Illinois No. 6 (3" x 0, compacted), Mine B
30% Eagle
15% Elkhorn
25% Pocahontas (low-volatile)

Date of test	Run 537E 6-16-60	Run 544E 7-12-60	Run 554E 8-9-60	Run 559E 9-22-60	Run 573E 11-8-60
Days since stockpiling Illinois coal	16	42	70	114	161
		Coke Physical Properties			
Tumbler test					
Stability	56.6	53.8	52.2	51.3	54.2
Hardness	65.5	62.7	63.9	62.8	64.2
Shatter test					
+2"	70.8	76.4	74.0	78.2	73.0
+1½"	89.2	92.5	90.5	91.5	90.5
Coke sizing					
+4"	4.7	4.2	3.7	5.9	5.5
4" x 3"	17.3	20.6	20.7	22.2	19.1
3" x 2"	44.0	43.4	42.3	42.4	41.4
2" x 1"	28.0	24.9	26.3	23.7	27.2
1" x ½"	2.0	1.7	2.1	2.0	2.1
-½"	4.0	5.2	4.9	3.8	4.7
Average size (in.)	2.36	2.39	2.37	2.48	2.39
Apparent gravity	0.82	0.78	0.81	0.82	0.82
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	70.5	70.0	70.0	71.1	70.5
Furnace (+1")	66.5	65.2	65.1	67.0	65.5
Nut (1" x ½")	1.4	1.2	1.5	1.4	1.6
Breeze (-½")	2.8	3.6	3.4	2.7	3.4
		Expansion Pressure			
Lbs. per sq. in.	0.8	0.75	0.55	0.5	0.7
Bulk density (lbs. per cu. ft.)	51.6	49.7	51.0	50.2	49.0
		Operating Data			
Pulverization (% -1/8")	81.7	84.3	77.8	80.1	78.5
Flue temp. (°F.)	1970	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30	16:30

TABLE F - COKING TEST RESULTS FOR COAL BLEND 6

45% Illinois No. 6 (3" x 0, uncompacted), Mine B
20% Elkhorn
35% Medium-volatile

Date of test	Run 524E 5-5-60	Run 541E 6-30-60	Run 550E 7-28-60	Run 557E 9-15-60	Run 571E 11-2-60
Days since stockpiling Illinois coal	Fresh	30	58	107	155
			Coke Physical Properties		
Tumbler test					
Stability	53.4	56.5	54.8	54.3	55.7
Hardness	65.3	66.6	65.2	64.2	65.8
Shatter test					
+2"	79.9	70.5	76.4	66.8	75.5
+1½"	93.1	91.0	92.6	91.3	90.8
Coke sizing					
+4"	5.0	1.6	2.5	1.8	3.3
4" x 3"	17.5	17.6	17.7	19.3	20.5
3" x 2"	47.7	49.0	48.7	48.2	46.1
2" x 1"	24.4	26.1	25.1	24.1	23.2
1" x ½"	2.0	2.0	1.9	1.9	1.7
-½"	3.4	3.7	4.1	4.7	5.2
Average size (in.)	2.42	2.33	2.35	2.35	2.39
Apparent gravity	0.82	0.83	0.80	0.80	0.81
		Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	71.8	70.9	71.4	71.1	72.2
Furnace (+1")	67.9	67.0	67.2	66.4	67.3
Nut (1" x ½")	1.4	1.3	1.3	1.3	1.2
Breeze (-½")	2.5	2.6	2.9	3.4	3.7
			Expansion Pressure		
Lbs. per sq. in.	0.7	0.9	0.5	0.5	0.7
Bulk density (lbs. per cu. ft.)	51.0	51.0	50.4	49.7	50.6
			Operating Data		
Pulverization (% -1/8")	80.2	82.5	80.3	82.9	82.3
Flue temp. (°F.)	1970	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30	16:30

TABLE G - COKING TEST RESULTS FOR COAL BLEND 7

45% Illinois No. 6 (3" x 1")
20% Elkhorn
35% Medium-volatile

Date of test	Run 523E 5-3-60	Run 535E 6-9-60	Run 542E 7-6-60	Run 551E 8-1-60	Run 556E 9-13-60	Run 570E 10-31-60
Days since stockpiling Illinois coal	1	38	65	90	133	181
			Coke Physical Properties			
Tumbler test						
Stability	53.3	55.2	55.6	53.2	53.5	57.4
Hardness	65.0	69.0	65.6	65.4	65.7	67.9
Shatter test						
+2"	67.6	72.5	73.8	73.1	67.8	73.7
+1½"	90.9	91.3	90.7	90.6	90.1	90.9
Coke sizing						
+4"	3.0	2.2	1.4	1.9	1.9	4.2
4" x 3"	18.4	16.2	17.9	20.5	19.3	18.8
3" x 2"	48.1	49.2	50.6	48.1	46.6	46.9
2" x 1"	25.0	26.7	24.1	23.2	26.0	24.7
1" x ½"	2.1	1.8	2.0	2.0	2.2	1.9
-½"	3.4	3.9	4.0	4.3	4.0	3.5
Average size (in.)	2.38	2.32	2.34	2.38	2.34	2.41
Apparent gravity	0.83	0.84	0.81	0.80	0.81	0.82
			Coke Yields (% of Coal) (Coke at 3% M; coal as received)			
Total	71.2	71.3	70.4	71.2	71.2	71.5
Furnace (+ 1")	67.3	67.2	66.2	66.7	66.8	67.6
Nut (1" x ½")	1.5	1.3	1.4	1.4	1.6	1.4
Breeze (-½")	2.4	2.8	2.8	3.1	2.8	2.5
			Expansion Pressure			
Lbs. per sq. in.	0.5	0.8	0.6	0.5	0.5	0.6
Bulk density (lbs. per cu. ft.)	51.4	53.6	50.0	50.4	50.0	52.0
			Operating Data			
Pulverization (% -1/8")	78.5	81.0	81.8	81.6	83.5	83.4
Flue temp. (°F.)	1970	1970	1970	1970	1970	1970
Coking time (hr. : min.)	16:30	16:30	16:30	16:30	16:30	16:30

Illinois State Geological Survey Circular 317
19 p., 3 figs., 3 tables, app., 1961

CIRCULAR 317

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA

572

41519 8-61