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WEATHERING OF ILLINOIS COALS DURING STORAGE

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ABSTRACT

No. 5 and No. 6 coals from southern Illinois, in the sizes supplied commercially for metallurgical coke, may be stocked out of doors for six months during the winter period without appreciable change in their coking properties. These same coals may be stocked for 30 days in warm summer weather, but longer summer storage may cause undesirable changes in coke structure. No. 6 coal weathers more rapidly than No. 5.

INTRODUCTION

Since 1944, southern Illinois coals have been used continuously in blends with coals from the East for production of metallurgical coke. Extended storage of these coals, especially of the smaller sizes, is known to result in oxidation, or weathering, which renders the coals less strongly coking. As weathering is a reaction between the coal surfaces and oxygen from the air, there are two methods by which it may be reduced or prevented. Either (1) air should be prevented from entering storage piles, or (2) surface area should be kept at a minimum by storing only the larger sized pieces.

Various methods developed for excluding air, such as packing coal fines tightly in storage piles with heavy bulldozers, are well known to the coal industry and have enabled utility and industrial plants to stock large tonnages of coal fines for extended periods without loss. Both utility and metallurgical plants have demonstrated that either high- or low-rank coals may be stored under water for long periods without appreciable deterioration.

Coal fines from the Illinois field should not be used for coke, partly because of the tendency to weather and partly because a large proportion of the total fusain is found in the fine portion of the coal. The larger, double-screened sizes have a relatively small surface area as compared with the fines, and we have found that the portion of coal with a bottom size no smaller than 3/4-inch may be stocked safely for limited periods without packing. We have recommended therefore that only the plus 3/4-inch sizes of Illinois coals be used by the coke industry, and that these sizes be coked within 30 to 90 days after mining to avoid the possibility of oxidation. These recommendations have been followed by the industry and, with few exceptions, only the freshly-mined, double-screened coals have been coked.

PREVIOUS WEATHERING TESTS

Although pilot plant tests had shown that both No. 5 and No. 6 coals could be stocked safely for 30 days, and in winter weather for much longer periods (Reed, 1947), we had no experience with stockpiling Illinois coals for commercial coke until the winter of 1945-46. In the fall of 1945 No. 6 coal, largely 6" x 3" and 3" x 2" from a number of mines, was stocked in a ridge-shaped pile approximately 150 feet long and 25 feet high on a concrete pad at a coke plant in the Chicago area. We sampled and tested this coal at intervals over a six-months period. The first two samples were taken from the top of the pile where the coal had been directly exposed to the weather. The six-month sample was taken from the center of the pile as coal was being removed from storage. Results of the coking tests, shown in table 1, indicate that six-months storage had not caused sufficient weathering to be noticeable when this coal was used as 25 percent of the total coal blend. Coal in the pile still showed the original bright surfaces, and there was no size degradation or evidence of heating. The commercial-oven coke made with this coal from storage was normal in every respect.

Table 1. - Illinois Coal Stocked in Plant Storage Pile During Winter Period

Coal blend: 25% Illinois No. 6
25% Eastern Kentucky
50% Pocahontas No. 4

Run No.	Time in storage, months	Shatter +2"	Tumbler Stability +1"	Tumbler Hardness $+\frac{1}{4}$"	Average size in.	Breeze $-\frac{1}{2}$" % of coal	Apparent gravity
220	1	64.0	31.3	64.0	2.55	3.0	.887
226	2	62.2	28.3	62.7	2.63	3.1	.889
254	6	62.9	34.5	65.4	2.63	3.1	.892

Table 2. - Illinois Coal Stocked Under Water April 1 through February 1

Coal blend: 25% Illinois No. 6
34% Hernshaw
35% Pocahontas No. 3
6% Anthracite

Run No.	Time in storage, months	Shatter +2"	Tumbler Stability +1"	Tumbler Hardness $+\frac{1}{4}$"	Average size in.	Breeze $-\frac{1}{2}$" % of coal	Apparent gravity
474-5	$1\frac{1}{2}$	87.5	48.6	55.1	3.41	2.0	.910
481-2	4	87.3	48.4	55.9	3.45	2.1	.912
483-4	$5\frac{1}{2}$	87.3	51.9	58.5	3.40	2.0	.920
485-6	10	88.6	51.6	59.5	3.42	2.0	.928

Another series of weathering tests was made in 1950-51 on No. 6 coal stocked under water for ten months in a Midwest coke plant. Underwater storage very effectively prevented contact of coal with air and thus prevented oxidation, even though the coal was stored during the entire summer when temperatures at times reached 100° F. Table 2 shows results of tests, made at intervals throughout the period, in the pilot coke oven from blends containing 25 percent of this coal. Fresh eastern coals were used in each test along with the Illinois coal from storage, and the small increase in coke strength in the final tests may have been due either to slight weathering of the Illinois coal or to nonuniformity of eastern coals.

NEED FOR NEW WEATHERING TESTS

In addition to the tests described above, other coals from a number of southern Illinois mines have been stocked at our laboratories and tested over a period of time. These studies have shown that weathering characteristics, although similar, are somewhat different for coals from the different seams, or from the same seam in different locations (Jackman, 1946). The last of these early tests was made in 1946, and the mines from which most of these coals were taken are now closed and replaced by newer mines, sometimes at a considerable distance from the older locations. It seemed desirable therefore to determine the weathering characteristics of coals from mines currently producing metallurgical coal, and to make this information available.

METHODS OF TESTING

It was known that the bituminous B rank coals mined in southern Illinois weather faster in hot weather than in cold. We decided, therefore, to make two series of tests, one covering the winter period from October through March, and the other the summer period from April through September.

Coals mined by three southern Illinois producers were tested, one from the No. 5 seam and two from the No. 6. All these coals have been used for commercial production of metallurgical coke, and each was sampled in the size range actually supplied to the industry. All sizes fall within the range of 3" x 1".

Approximately 2 1/2 tons of each Illinois coal were taken at the mines in such a way that all working faces were represented. These coals were stocked out-of-doors in conical piles about six feet in diameter. In such small piles the coals were subject to a maximum exposure to the weather.

At intervals of about one month a sample of 500 pounds was taken from the outside of each pile, and blends of 75 percent Illinois coal and 25 percent Pocahontas were tested in the Survey's movable-wall pilot coke oven (Jackman, 1955). These blends were carbonized in 16 1/2 hours under standard operating conditions so that the cokes produced were comparable with commercial oven coke. The Pocahontas slack used in all blends was stocked during the period of the tests in an outside covered bin partially open on one side to the atmosphere. Fresh Pocahontas coal was obtained at the start of the second testing period so that no coal remained in stock longer than six months.

The extent of weathering of the coals was judged by analytical determinations of Gieseler fluidity and free swelling index, by changes in the physical properties of cokes produced in the pilot oven, and by trends in expansion pressure. The physical properties affected primarily by weathering were the tumbler indices and coke size, particularly the proportion of fines. Apparent gravity also tended to change as weathering progressed.

We wish to thank each of the coal producers who furnished the Illinois coals used in the tests reported here. Also, we thank the Wisconsin Steel Company of Chicago for furnishing the Pocahontas coal used for blending.

RESULTS OF TESTS

Winter Storage

Tests on the three Illinois coals through the winter period paralleled our former experience with coals no longer mined, and indicated that very little weathering takes place during cold weather. Table 3 shows analyses and plastic properties of the coals being tested. Tables 4, 5, and 6 give pilot plant data for the six-month period, and figures 1 through 5 show certain of these data in graphical form from which the degree of weathering may be judged more easily.

Table 3. - Coals Placed in Winter Storage
Analyses and Plastic Properties

Coal	M.	Analyses Moisture-free basis V.M.	F.C.	Ash	Sulfur	F.S.I.
Illinois No. 5 Mined 9-27-55	7.0	37.5	54.9	7.6	1.69	7
Illinois No. 6A Mined 10-18-55	8.6	39.0	53.2	7.8	1.77	5½
Illinois No. 6B Mined 10-3-55	8.6	37.7	54.5	7.8	1.02	5½
Pocahontas	4.2	17.1	76.1	6.8	0.58	9

Plastic Properties

	Gieseler Fluidity Dial div. per min.	at °C	Plastic Range (°C) Softening	Solidification
Illinois No. 5	116	436	385	464
Illinois No. 6A	14	427	388	459
Illinois No. 6B	10.8	427	388	453
Pocahontas	7	486	451	510

No. 5 coal is shown to be especially stable during winter storage, and showed no significant changes in the yield of coke breeze throughout the period. The tumbler stability gradually increased for about 100 days, then stayed above the value for fresh coal until the sixth-month test.

The No. 6 coals likewise changed very little during this period. Breeze remained very constant for about four months, then increased slightly, especially with the No. 6B coal blend. However, the increase in yield of breeze over that from the fresh coal never exceeded 1.0 percent.

Tumbler stability showed a tendency to increase with the No. 6 coals after three to five months in storage. Otherwise, stability indices remained practically constant throughout the entire period. Tumbler hardness tended to decrease only slightly on coke from the No. 6B coal, especially in the last two months. This coincided with the small increase in breeze.

There were no significant changes in expansion pressures exerted by these blends over the winter period. Likewise, there was no well defined trend in coke gravity.

Plasticity and swelling indices determined over the six months period, and shown in table A of the appendix, are fairly constant within the accuracy of

Table 4. - Coking Tests with Illinois No. 5
(Winter Period)

Coal blend: 75% Illinois No. 5
(Mined 9-27-55)
25% Pocahontas

	Run 154E	Run 160E	Run 167E	Run 173E	Run 181E	Run 186E	Run 194E
Date of test	10-11-55	11-8-55	12-6-55	1-10-56	2-7-56	3-1-56	3-29-56
Days since mining Ill. coal	14	42	70	105	133	156	184
			Coke physical properties				
Tumbler test							
Stability	57.1	57.0	57.8	59.8	58.3	58.1	56.4
Hardness	67.3	67.0	67.5	66.7	66.8	66.5	66.4
Shatter test							
+2"	78.8	81.8	81.9	75.6	82.1	83.9	79.2
+1½"	93.0	93.8	93.9	92.2	93.5	94.3	93.4
+1"	97.4	97.4	97.7	97.1	97.8	98.0	97.5
Coke sizing							
+4"	5.7	5.0	7.5	6.2	8.3	6.2	5.7
4" x 3"	20.1	16.6	28.6	28.0	32.2	24.6	22.8
3" x 2"	46.7	48.0	36.7	39.9	37.5	40.5	44.2
2" x 1"	21.5	24.5	22.1	19.4	16.4	22.3	20.7
1" x ½"	1.6	1.7	1.4	2.1	1.4	2.3	2.3
-½"	4.7	4.2	3.7	4.4	4.2	4.1	4.3
Average size (in.)	2.47	2.40	2.61	2.57	2.71	2.51	2.50
Apparent gravity	.827	.831	.834	.825	.839	.824	.828
			Coke yields (% of coal) (Coke at 3% M. - coal as received)				
Total	70.4	69.7	69.8	70.6	70.3	69.7	69.4
Furnace (+1")	66.2	65.6	66.2	66.0	66.4	65.3	64.8
Nut (1" x ½")	1.1	1.2	1.0	1.5	1.0	1.6	1.6
Breeze (-½")	3.1	2.9	2.6	3.1	2.9	2.8	3.0
			Expansion pressure				
Lbs. per sq. in.	1.37	1.32	1.28	1.35	1.20	1.28	1.17
Bulk density (Lbs. per cu.ft.)	51.1	50.7	51.1	50.7	50.7	50.7	51.1
			Operating data				
Pulverization (-1/8")	81.6	82.0	80.7	83.2	84.1	82.0	82.3
Flue temp. (°F)	1900	1900	1900	1900	1900	1900	1900
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30	16:30	16:30

Table 5. - Coking Tests with Illinois No. 6A
(Winter Period)

Coal blend: 75% Illinois No. 6A
(Mined 10-18-55)
25% Pocahontas

	Run 156E	Run 164E	Run 169E	Run 176E	Run 184E	Run 191E	Run 198E
Date of test	10-25-55	11-22-55	12-20-55	1-19-56	2-16-56	3-20-56	4-17-56
Days since mining Ill. coal	7	35	63	93	121	154	182
			Coke physical properties				
Tumbler test							
Stability	55.8	55.8	56.0	56.8	56.3	57.5	55.3
Hardness	66.0	66.9	66.1	65.3	65.8	66.4	65.6
Shatter test							
+2"	79.3	79.3	78.5	83.5	78.1	83.0	84.1
+1½"	93.2	92.5	92.7	94.5	92.3	93.6	94.1
+1"	97.0	97.0	97.0	97.5	97.0	97.3	96.8
Coke sizing							
+4"	6.1	4.1	8.0	7.2	7.1	10.0	9.0
4" x 3"	21.5	18.4	33.6	22.7	23.9	36.2	22.4
3" x 2"	43.1	46.1	35.6	44.2	43.7	33.0	41.0
2" x 1"	23.1	25.4	16.5	19.3	17.9	14.0	20.0
1" x ½"	1.8	1.7	2.0	2.0	2.4	1.3	2.8
-½"	4.4	4.3	4.3	4.6	5.0	5.5	4.8
Average size (in.)	2.48	2.39	2.70	2.54	2.55	2.78	2.55
Apparent gravity	.815	.809	.804	.812	.809	.801	.824
			Coke yields (% of coal) (Coke at 3% M. - coal as received)				
Total	68.4	68.0	68.3	68.8	67.7	68.9	67.8
Furnace (+1")	64.2	64.0	64.0	64.3	62.7	64.2	62.7
Nut (1" x ½")	1.2	1.1	1.4	1.4	1.6	0.9	1.9
Breeze (-½")	3.0	2.9	2.9	3.1	3.4	3.8	3.2
			Expansion pressure				
Lbs. per sq. in.	1.07	1.05	1.11	1.08	1.15	0.99	1.20
Bulk density (Lbs. per cu. ft.)	50.8	51.4	51.1	50.7	50.7	50.7	51.1
			Operating data				
Pulverization (-1/8")	82.5	84.2	82.4	80.0	86.0	85.5	83.6
Flue temp. (°F)	1900	1900	1900	1900	1900	1900	1900
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30	16:30	16:30

Table 6. - Coking Tests with Illinois No. 6B
(Winter Period)

Coal blend: 75% Illinois No. 6B
(Mined 10-3-55)
25% Pocahontas

	Run 155E	Run 161E	Run 168E	Run 174E	Run 182E	Run 188E	Run 196E
Date of test	10-14-55	11-10-55	12-15-55	1-12-56	2-9-56	3-8-56	4-5-56
Days since mining Ill. coal	11	38	73	101	129	157	185
			Coke physical properties				
Tumbler test							
Stability	56.5	56.1	55.4	56.2	55.9	55.0	55.6
Hardness	66.5	66.9	66.2	65.3	65.7	64.2	64.8
Shatter test							
+2"	78.2	80.3	81.0	82.0	80.4	87.5	83.9
+1½"	93.8	92.8	93.8	93.3	92.5	95.5	93.3
+1"	97.3	96.9	97.2	97.1	97.0	97.8	97.0
Coke sizing							
+4"	6.2	9.3	7.0	6.7	8.7	9.0	9.4
4" x 3"	28.6	32.8	25.7	28.8	25.4	27.2	23.3
3" x 2"	41.3	34.7	42.0	39.4	41.8	39.3	39.3
2" x 1"	17.0	16.6	18.3	17.0	16.8	16.6	19.3
1" x ½"	1.9	2.1	2.0	2.3	2.3	2.0	2.4
-½"	5.0	4.5	5.0	5.8	5.0	5.9	6.3
Average size (in.)	2.60	2.71	2.57	2.58	2.61	2.62	2.54
Apparent gravity	.818	.812	.802	.817	.821	.825	.818
			Coke yields (% of coal) (Coke at 3% M. - coal as received)				
Total	68.0	68.3	68.4	68.2	67.3	68.4	68.0
Furnace (+1")	63.4	63.7	63.6	62.8	62.4	63.0	62.1
Nut (1" x ½")	1.3	1.5	1.4	1.5	1.5	1.3	1.6
Breeze (-½")	3.3	3.1	3.4	3.9	3.4	4.1	4.3
			Expansion pressure				
Lb. per sq. in.	0.88	0.79	0.94	0.94	0.97	1.06	0.91
Bulk density (Lbs. per cu ft.)	51.6	50.7	50.3	50.7	51.1	50.7	51.1
			Operating data				
Pulverization (-1/8")	81.5	81.1	82.6	82.0	82.8	82.6	83.6
Flue temp. (°F)	1900	1900	1900	1900	1900	1900	1900
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30	16:30	16:30

these determinations. Other analytical data including the analysis and plastic properties of each coal blend, and analyses of the cokes produced, are shown in tables B, C, and D.

Summer Storage

The coals stored over the summer period, and tested at monthly intervals, oxidized far more rapidly than did those stored during the winter. The Gieseler fluidity of each coal decreased, and there were corresponding reductions in the fluidity of the blends. The free swelling index of the individual coals did not appear to change greatly during storage, but this index decreased consistently on the blends prepared for coking. Analyses and plastic properties of the fresh coals are shown in table 7. Tables 8, 9, and 10 show the results of coking tests made during the summer, and tables E, F, G, and H of the appendix show plasticity trends and analyses of coals and blends throughout the period.

Table 7. - Coals Placed in Summer Storage
Analyses and Plastic Properties

Coal	M.	Analyses, Moisture-free basis: V.M.	F.C.	Ash	Sulfur	F.S.I.
Illinois No. 5 Mined 4-12-56	6.4	37.5	55.1	7.4	1.44	6½
Illinois No. 6A Mined 5-8-56	8.1	37.9	54.3	7.8	1.25	4½
Illinois No. 6B Mined 5-3-56	8.4	38.6	53.5	7.9	1.18	4½
Pocahontas	3.6	17.8	76.5	5.7	0.61	9

Plastic Properties

	Gieseler Fluidity: Dial div. per min.	at °C	Plastic Range (°C): Softening	Solidification
Illinois No. 5	118	432	386	463
Illinois No. 6A	18	430	389	455
Illinois No. 6B	34	426	348	458
Pocahontas	73	486	439	509

Results of the pilot oven tests indicate that there was little oxidation in any of the three coals during the first 30 days of storage, and that any of these coals might be stored safely for that length of time. Following this 30-day period, breeze (minus 1/2" coke fines) production increased rapidly with the No. 6A coal blend, and less rapidly with the other two. Tests on the No. 6A coal were discontinued after four months because of excessive breeze production; No. 6B tests were continued for five months before breeze production made further testing impractical, and No. 5 coal tests were continued for the full six-months period.

Even though the increase in coke breeze indicated weathering, the tumbler indices did not respond as quickly. Cokes made from No. 5 and No. 6B blends increased in stability and hardness during the first 60 days of coal storage. Stability did not fall below the value for fresh coal for over four months, and hardness for nearly as long. The coke made from No. 6A coal maintained prac-

Table 8. - Coking Tests with Illinois No. 5
(Summer Period)

Coal blend: 75% Illinois No. 5
(Mined 4-12-56)
25% Pocahontas

	Run 199E	Run 205E	Run 212E	Run 222E	Run 227E	Run 235E
Date of test	4-19	5-17	6-14	7-24	9-6	10-11
Days since mining Ill. coal	7	35	63	103	147	182
			Coke physical properties			
Tumbler test						
Stability	57.3	55.7	59.1	58.1	56.1	54.7
Hardness	67.3	65.9	68.4	67.5	65.2	64.8
Shatter test						
+2"	82.3	77.4	80.5	78.7	78.7	77.5
+1½"	93.5	92.8	92.0	93.1	93.0	92.1
+1"	97.0	96.5	96.8	97.0	97.3	96.2
Coke sizing						
+4"	5.3	4.8	5.3	6.3	5.2	7.8
4" x 3"	36.6	25.0	25.5	19.8	23.6	20.5
3" x 2"	36.1	44.3	45.6	45.9	43.9	43.3
2" x 1"	17.0	19.5	17.0	19.8	17.4	19.2
1" x ½"	1.0	2.1	1.5	1.9	2.1	2.0
-½"	4.0	4.3	5.1	6.3	7.8	7.2
Average size (in.)	2.69	2.52	2.55	2.45	2.45	2.47
Apparent gravity	.806	.813	.830	.821	.828	.829
			Coke yields (% of coal) (Coke at 3% M. - coal as received)			
Total	70.3	72.0	70.5	70.2	69.5	71.4
Furnace (+1")	66.7	67.4	65.8	64.5	62.7	64.8
Nut (1" x ½")	0.7	1.5	1.1	1.3	1.4	1.4
Breeze (-½")	2.9	3.1	3.6	4.4	5.4	5.2
			Expansion pressure			
Lbs. per sq. in.	1.36	1.27	1.19	0.95	0.86	0.80
Bulk density (Lbs. per cu. ft.)	51.5	51.1	51.1	51.1	51.1	50.7
			Operating data			
Pulverization (-1/8")	79.0	82.7	81.3	82.6	85.7	83.5
Flue temp. (°F)	1900	1925	1925	1925	1925	1925
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30	16:30

Table 9. - Coking Tests with Illinois No. 6A
(Summer Period)

Coal blend: 75% Illinois No. 6A
(Mined 5-8-56)
25% Pocahontas

	Run 204E	Run 211E	Run 218E	Run 226E	Run 229E
Date of test	5-15	6-12	7-10	8-7	9-13
Days since mining Ill. coal	7	35	63	91	128
			Coke physical properties		
Tumbler test					
Stability	55.5	54.6	55.6	49.8	47.9
Hardness	66.2	66.2	65.5	61.9	58.3
Shatter test					
+2"	73.5	79.5	73.3	75.7	79.7
+1½"	91.0	93.5	91.1	90.7	92.0
+1"	96.8	97.3	95.9	95.9	95.3
Coke sizing					
+4"	5.3	3.9	7.2	5.8	6.6
4" x 3"	22.9	21.1	23.8	23.0	23.9
3" x 2"	42.4	47.4	40.4	43.4	37.7
2" x 1"	21.9	19.9	18.6	17.2	17.4
1" x ½"	2.4	2.5	1.8	1.8	2.6
-½"	5.0	5.2	8.2	8.8	11.8
Average size (in.)	2.46	2.43	2.48	2.44	2.39
Apparent gravity	.783	.813	.812	.816	.832
			Coke yields (% of coal) (Coke at 3% M. - coal as received)		
Total	69.4	68.7	68.8	67.2	68.6
Furnace (+1")	64.3	63.4	62.0	60.1	58.7
Nut (1" x ½")	1.7	1.7	1.2	1.2	1.8
Breeze (-½")	3.4	3.6	5.6	5.9	8.1
			Expansion pressure		
Lbs. per sq. in.	1.14	1.00	0.82	0.84	0.75
Bulk density (Lbs. per cu. ft.)	51.5	51.1	51.1	51.1	51.1
			Operating data		
Pulverization (-1/8")	80.3	84.2	84.9	82.0	82.8
Flue temp. (°F)	1925	1925	1925	1925	1925
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30

Table 10. - Coking Tests with Illinois No. 6B
(Summer Period)

Coal blend: 75% Illinois No. 6B
(Mined 5-3-56)
25% Pocahontas

	Run 203E	Run 209E	Run 217E	Run 225E	Run 228E	Run 234E
Date of test	5-10	6-5	7-3	8-2	9-11	10-9
Days since mining Ill. coal	7	33	61	91	131	159
			Coke physical properties			
Tumbler test						
Stability	55.9	57.3	58.0	56.8	56.6	54.2
Hardness	65.9	66.4	67.2	65.1	64.5	62.7
Shatter test						
+2"	80.6	79.1	77.8	79.5	82.2	77.3
+1½"	93.4	93.8	93.1	92.4	95.6	92.8
+1"	97.1	97.7	97.0	96.9	97.0	97.2
Coke sizing						
+4"	7.9	4.6	4.8	6.9	8.1	6.5
4" x 3"	36.5	21.9	24.0	21.9	25.4	25.0
3" x 2"	32.5	48.1	43.9	44.3	38.3	36.7
2" x 1"	16.8	18.2	18.8	17.0	18.1	20.2
1" x ½"	1.8	2.3	2.1	2.1	1.7	1.5
-½"	4.5	4.9	6.4	7.8	8.4	10.1
Average size (in.)	2.72	2.48	2.47	2.46	2.52	2.42
Apparent gravity	.793	.790	.798	.807	.802	.816
			Coke yields (% of coal) (Coke at 3% M. - coal as received)			
Total	68.7	68.5	67.0	68.0	68.5	69.8
Furnace (+1")	64.4	63.6	61.3	61.4	61.6	61.8
Nut (1" x ½")	1.2	1.5	1.4	1.4	1.1	1.0
Breeze (-½")	3.1	3.4	4.3	5.2	5.8	7.0
			Expansion pressure			
Lbs. per sq. in.	1.18	-	1.06	0.86	0.87	0.89
Bulk density (Lbs. per cu. ft.)	51.4	51.1	51.1	51.1	51.1	50.7
			Operating data			
Pulverization (-1/8")	77.5	83.2	84.3	83.4	84.7	86.4
Flue temp. (°F)	1925	1925	1925	1925	1925	1925
Coking time (Hr.:min.)	16:30	16:30	16:30	16:30	16:30	16:30

tically constant tumbler indices for 60 days, after which the quality deteriorated rapidly.

Expansion pressure exerted by all blends decreased from the start. The pressure exerted by No. 5 and No. 6B blends dropped slowly for 60 days and then changed more rapidly. A substantial drop in pressure occurred after 30 days with the No. 6A blend, indicating more rapid weathering.

Cokes from all blends showed a definite trend upward in apparent gravity. Here again, No. 5 showed the least change, and No. 6A the greatest. All of these critical properties of the cokes are plotted against time of storage in figures 1 through 5.

Judging from the analytical and pilot plant tests, it is evident that No. 5 coal resists oxidation longer than coals from No. 6 seam, and that coal No. 5 might be stocked for as long as 60 days in summer weather without serious effects. It would appear, however, that the No. 6 coals should not be stocked longer than 30 days in the summer.

The two No. 6 seam coals tested give evidence that coals from different areas in this seam may produce cokes of equal quality when fresh, but may differ in their ability to withstand weathering beyond the 30-day period. We can not adequately explain this difference in coking properties. The Gieseler fluidity of the fresh No. 6B coal was nearly twice that of the fresh No. 6A. However, after 30 days storage their fluidities were approximately the same. Likewise, free swelling indices of the two coals were practically identical throughout the period. Therefore, tendencies of the two coals to weather at different rates after 30 days cannot be correlated directly with either of these properties.

It is possible that the Pocahontas coal may have been partly responsible for the weathering trends noted throughout the summer series. Although this coal was fresh when stocked, and no change was noted in free swelling index over the six months, the fluidity did decrease with time. We plan to make another series of tests during summer weather with at least one of these coals in which the Pocahontas is stored under water to minimize any possible oxidation.

SUMMARY AND CONCLUSIONS

To summarize, we have studied the weathering properties of Illinois No. 5 and No. 6 coals stored out-of-doors in small conical piles so as to be subjected to a maximum amount of oxidation. We have found that these coals, in the size range 3" x 1", can be stocked during the six-months winter period without appreciable loss in coking properties. The same coals stocked during the summer period of warm weather showed little effect of weathering during the first 30 days, but after two months storage their coking properties started to change, and became progressively poorer as storage continued. Changes were more gradual in the No. 5 coal which might be stocked safely beyond the 30 days period. No. 6 coals from two mines weathered differently during summer storage, one showing much greater loss in coking properties than the other. Early tests have shown, however, that coal from this seam might be kept without oxidation throughout the year by storing under water.

From these tests we conclude that double-screened coal from No. 5 and No. 6 seams in southern Illinois, in the sizes being supplied to metallurgical coke plants, can be stocked safely in contact with air, and without packing, during the six-months winter period at temperatures prevailing in the Chicago and central Illinois district. In summer appreciable oxidation occurs during storage, although to a greater extent with No. 6 coal than with No. 5. It appears, however, that for best coking results none of these coals should be stocked in the usual storage piles in warm weather longer than 30 days.

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Reed, F. H., et al., 1947, Use of Illinois coal for production of metallurgical coke: Illinois Geol. Survey Bull. 71.

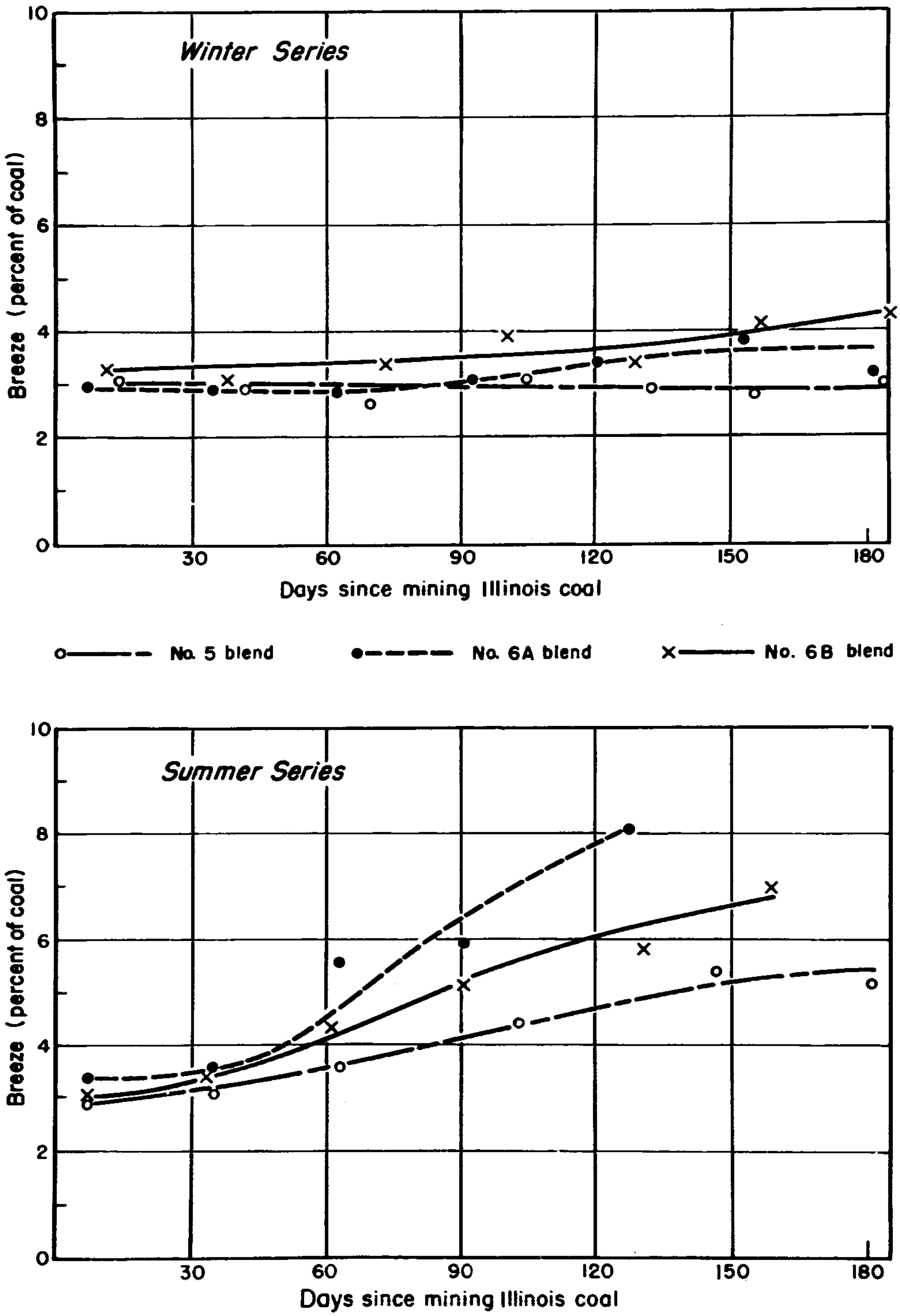

Fig. 1. - Coke breeze.

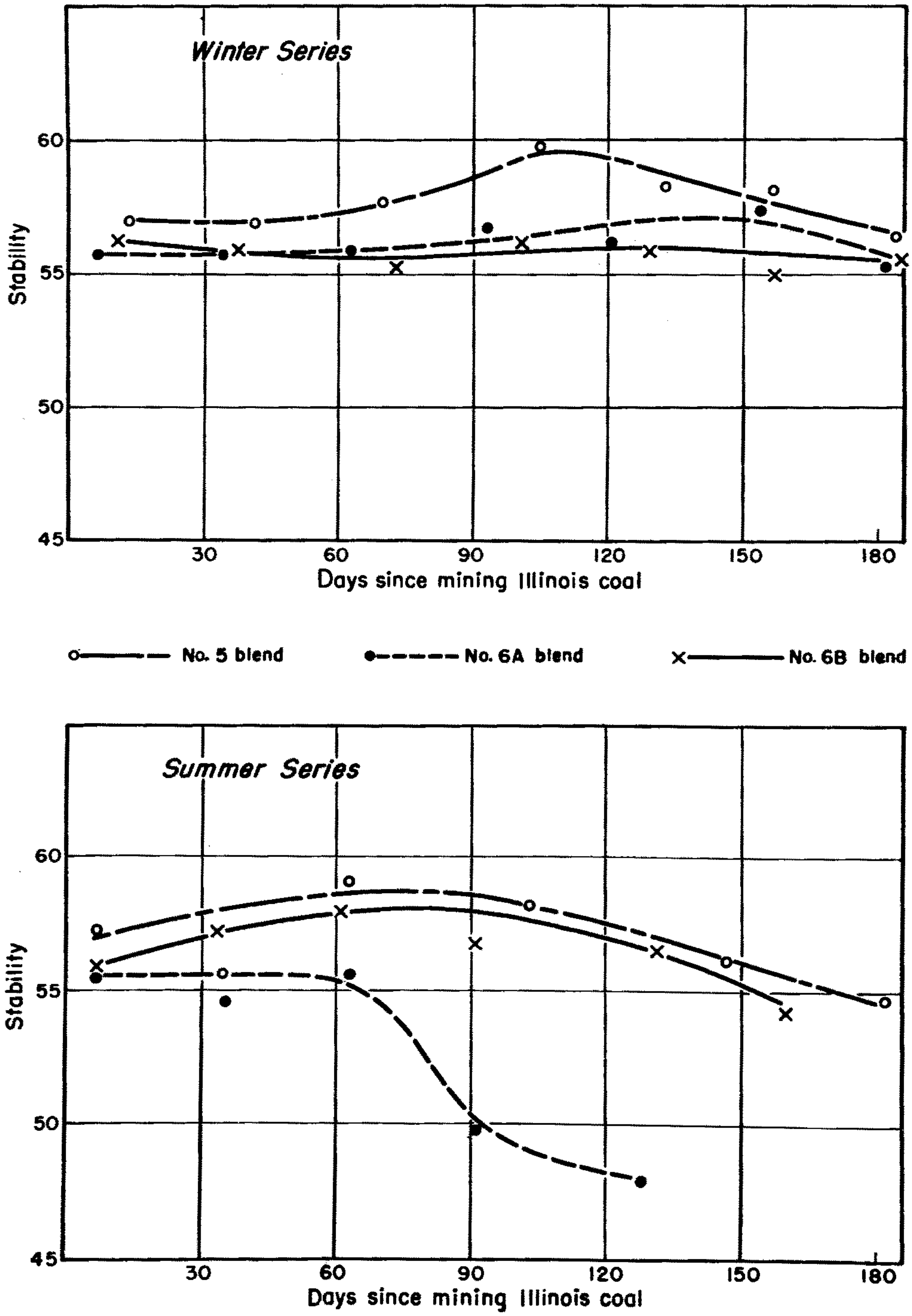

Fig. 2. - Tumbler stability.

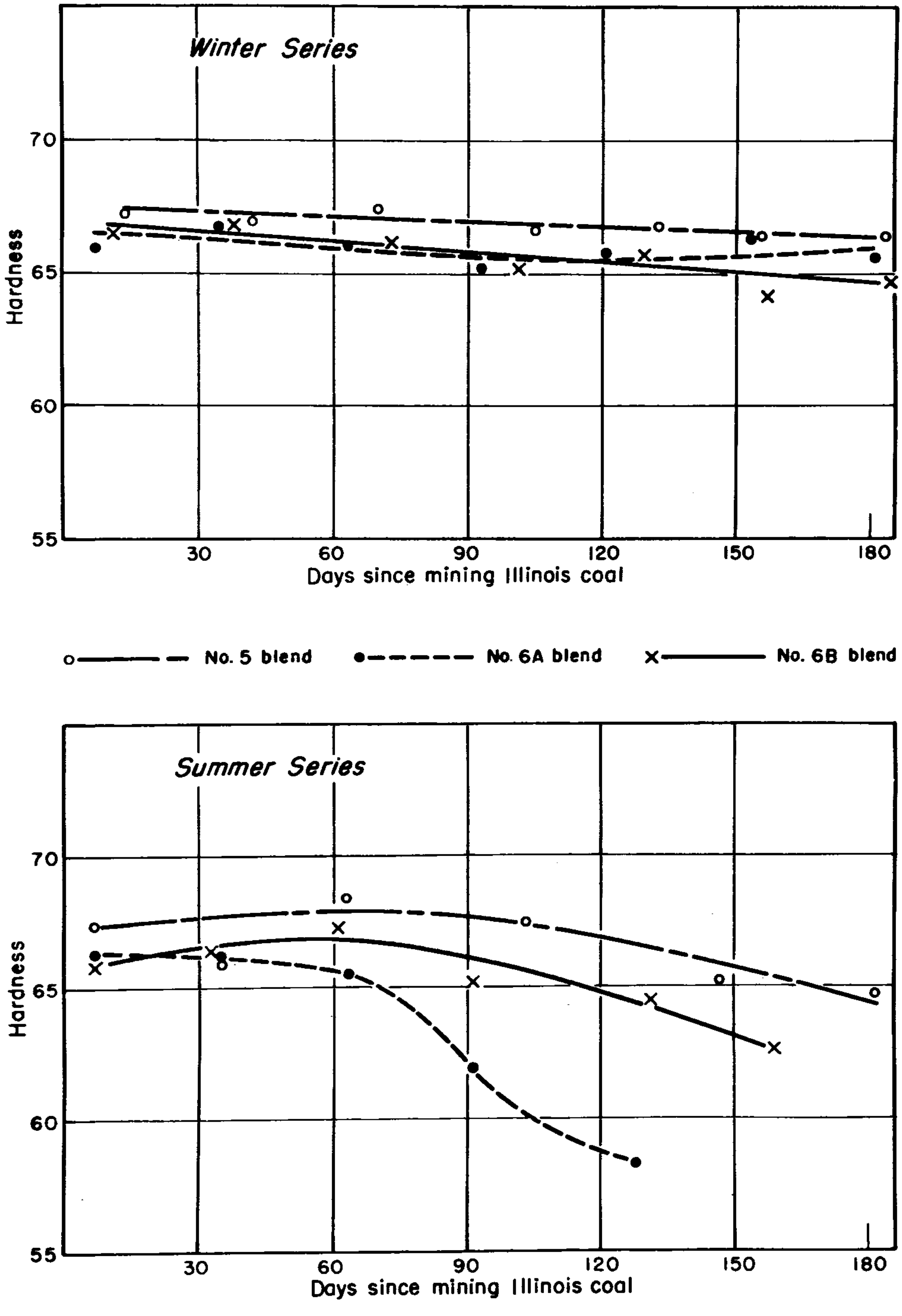

Fig. 3. - Tumbler hardness.

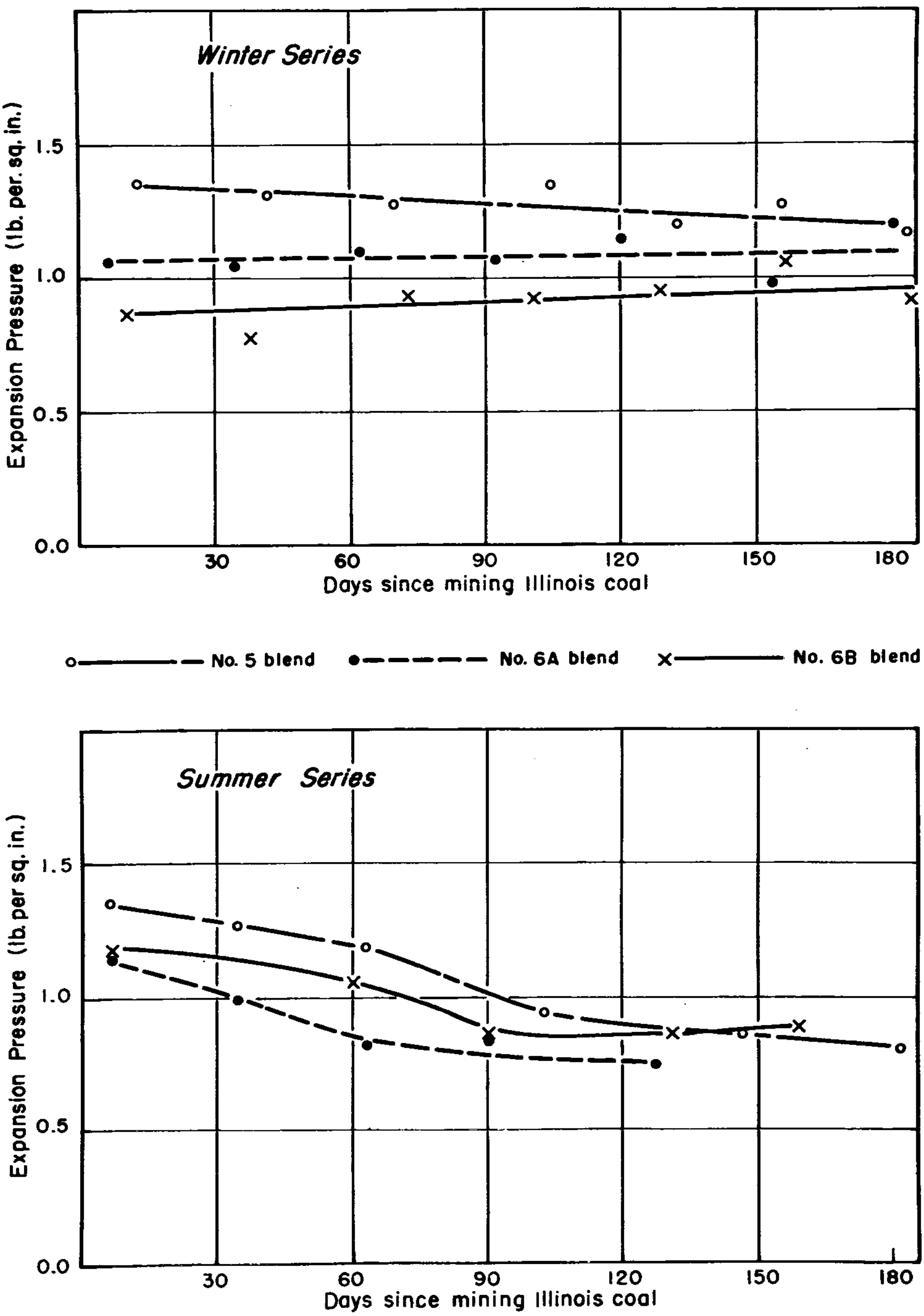

Fig. 4. - Expansion pressure.

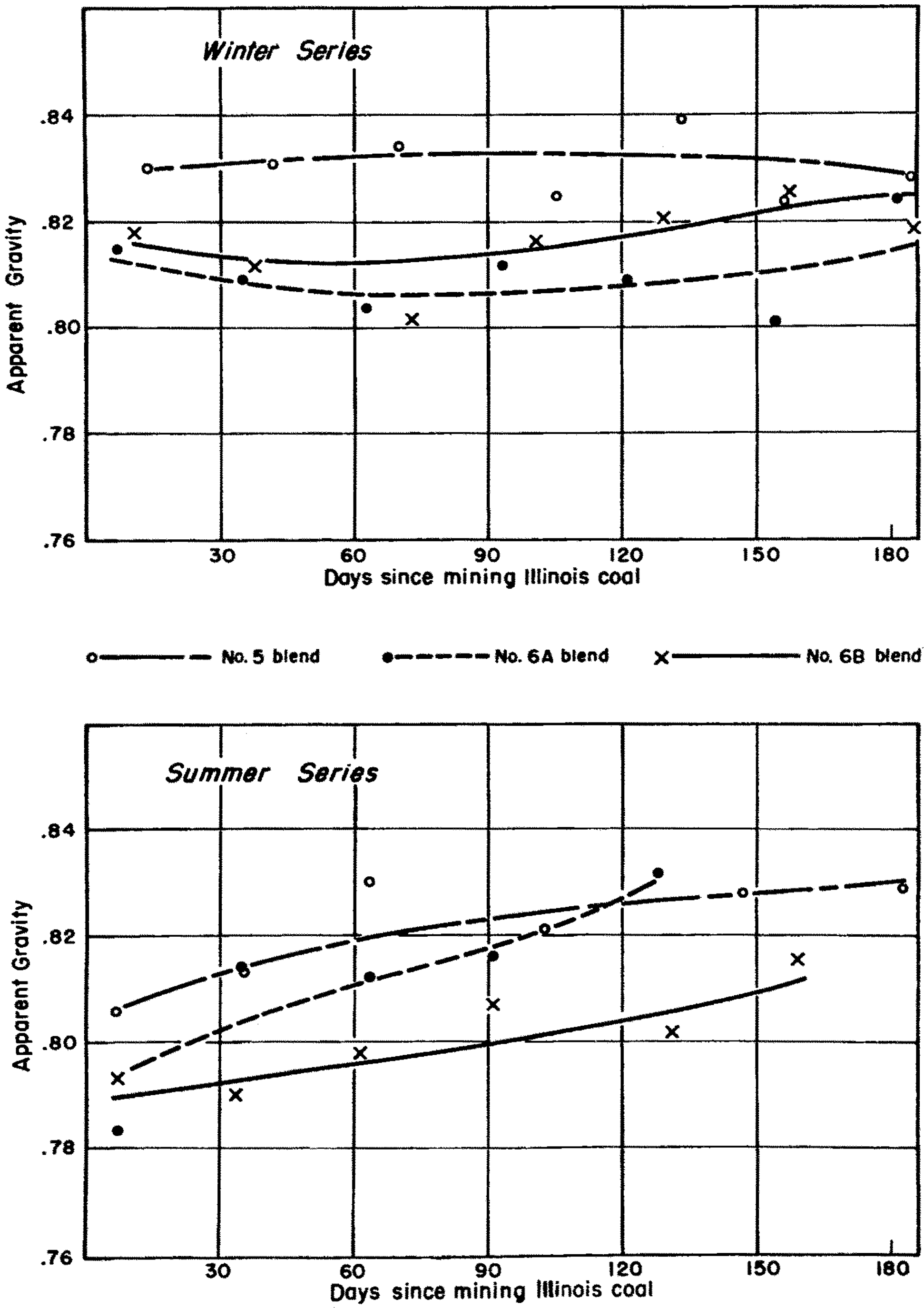

Fig. 5. - Apparent gravity.

APPENDIX

Analyses of Coals and Cokes, and Other Pertinent Data

Table A. - Plastic and Swelling Properties of Coals
(Winter Period)

Coal	Date	Maximum Gieseler fluidity	F.S.I.	Coal	Date	Maximum Gieseler fluidity	F.S.I.
Ill.	10-11-55	116	7	Ill. No. 6B	10-14-55	10.8	5½
No. 5	11- 8-55	68	6		11-10-55	11	5½
	12- 6-55	64	6½		12-15-55	11	6
	1-10-56	66	6½		1-12-56	8	5½
	2- 7-56	116	7		2- 9-56	22	5
	3- 1-56	90	7		3- 8-56	15	5
	3-29-56	67	5½		4- 5-56	10	5
Ill.	10-25-55	14	5½	Pocahontas	10- 5-55	7	9
No. 6A	11-22-55	27	5		12- 6-55	4	9
	12-20-55	22	6		1-24-56	3	9
	1-19-56	39	5		2- 9-56	6	8½
	2-16-56	29	5		3- 1-56	4	9
	3-20-56	34	5		3-23-56	5	9
	4-17-56	38	4½				

Table B. - Analytical Data for Coke Runs Shown in Table 4
(Winter Period)

Coal blend: 75% Illinois No. 5
25% Pocahontas

Run		M.	Moisture-free basis				Gieseler fluidity	F.S.I.
			V.M.	F.C.	Ash	Sulfur		
154E	Coal blend	4.8	32.5	60.3	7.2	1.47	16	7
	Coke		1.2	88.9	9.9	1.17		
160E	Coal blend	4.4	32.2	60.5	7.3	1.39	10	6
	Coke		1.6	87.2	11.2	1.05		
167E	Coal blend	4.1	32.2	60.5	7.3	1.41	14	6½
	Coke		1.5	88.4	10.1	1.07		
173E	Coal blend	4.0	31.9	60.8	7.3	1.39	14	5½
	Coke		1.2	88.7	10.1	1.12		
181E	Coal blend	4.4	32.8	59.8	7.4	1.45	25	6
	Coke		1.5	88.4	10.1	0.99		
186E	Coal blend	4.5	32.3	60.7	7.0	1.38	9	6½
	Coke		1.8	88.5	9.7	1.04		
194E	Coal blend	4.1	32.2	60.5	7.3	1.38	13	5½
	Coke		1.4	88.5	10.1	1.10		

Table C. - Analytical Data for Coke Runs Shown in Table 5
(Winter Period)

Coal blend: 75% Illinois No. 6A
25% Pocahontas

Run		M.	V.M.	F.C.	Ash	Sulfur	Gieseler fluidity	F.S.I.
			Moisture-free basis					
156E	Coal blend	5.3	33.0	59.7	7.3	1.35	4.5	5
	Coke		1.1	88.7	10.2	0.93		
164E	Coal blend	5.1	32.5	60.4	7.1	1.29	6	5
	Coke		1.3	88.5	10.2	0.95		
169E	Coal blend	4.8	33.5	59.1	7.4	1.33	11	5
	Coke		1.1	88.5	10.4	0.95		
176E	Coal blend	5.5	33.9	58.8	7.3	1.28	5	5½
	Coke		1.6	88.0	10.4	0.95		
184E	Coal blend	5.6	32.9	59.8	7.3	1.31	14	5½
	Coke		1.5	88.2	10.3	0.94		
191E	Coal blend	5.2	33.6	59.1	7.3	1.33	9	5
	Coke		1.6	88.2	10.2	0.90		
198E	Coal blend	5.1	33.5	59.1	7.4	1.48	7	5
	Coke		1.8	87.8	10.4	1.05		

Table D. - Analytical Data for Coke Runs Shown in Table 6
(Winter Period)

Coal blend: 75% Illinois No. 6B
25% Pocahontas

Run		M.	V.M.	F.C.	Ash	Sulfur	Gieseler fluidity	F.S.I.
			Moisture-free basis					
155E	Coal blend	6.2	33.3	59.1	7.6	1.04	6	5
	Coke		1.7	87.5	10.8	0.78		
161E	Coal blend	5.6	32.7	59.7	7.6	-	3.2	5
	Coke		1.5	87.8	10.7	0.75		
168E	Coal blend	4.4	32.9	59.5	7.6	1.05	11	6
	Coke		1.1	88.3	10.6	0.74		
174E	Coal blend	5.5	32.4	60.1	7.5	0.99	5	4½
	Coke		1.6	87.9	10.5	0.79		
182E	Coal blend	5.8	33.0	59.3	7.7	0.99	7	5½
	Coke		1.5	88.1	10.4	0.75		
188E	Coal blend	6.1	32.5	60.0	7.5	1.01	5	4½
	Coke		1.6	87.8	10.6	0.75		
196E	Coal blend	6.3	33.6	59.1	7.3	1.01	6	4½
	Coke		1.6	87.9	10.5	0.77		

Table E. - Plastic and Swelling Properties of Coals
(Summer Period)

Coal	Date	Maximum Gieseler fluidity	F.S.I.	Coal	Date	Maximum Gieseler fluidity	F.S.I.
Ill. No. 5	4-19-56	118	6½	Ill. No. 6B	5-10-56	34	4½
	5-17-56	39	5½		6- 5-56	13	5
	6-14-56	29	6		7- 3-56	6	5
	7-14-56	15	6½		8- 2-56	6	4½
	9- 6-56	8	5½		9-11-56	3	5½
	10-11-56	7	5½		10- 9-56	3	4½
Ill. No. 6A	5-15-56	18	4½	Pocahontas	4-12-56	73	9
	6-12-56	12	5		7- 9-56	11	9
	7-10-56	7	5½		7-24-56	13	9
	8- 7-56	5	6		9-11-56	7	9
	9-13-56	3	4		10-11-56	7	9

Table F. - Analytical Data for Coke Runs Shown in Table 8
(Summer Period)

Coal blend: 75% Illinois No. 5
25% Pocahontas

Run		M.	V.M.	F.C.	Ash	Sulfur	Gieseler fluidity	F.S.I.
			Moisture-free basis					
199E	Coal blend	4.8	32.5	60.6	6.9	1.32	26	7½
	Coke		1.7	88.9	9.4	1.04		
205E	Coal blend	4.9	32.1	60.9	7.0	1.25	10	5½
	Coke		1.8	88.8	9.4	0.99		
212E	Coal blend	5.2	32.2	60.8	7.0	1.35	8	5½
	Coke		1.5	89.0	9.5	1.06		
222E	Coal blend	5.4	32.0	61.1	6.9	1.34	5	5
	Coke		1.3	89.3	9.4	1.05		
227E	Coal blend	4.8	31.6	61.5	6.9	1.29	3	4
	Coke		1.2	89.0	9.8	1.04		
235E	Coal blend	3.7	31.9	60.9	7.2	1.43	3	5
	Coke		1.0	89.2	9.8	1.11		

Table G. - Analytical Data for Coke Runs Shown in Table 9
(Summer Period)

Coal blend: 75% Illinois No. 6A
25% Pocahontas

Run		M.	V.M.	F.C.	Ash	Sulfur	Gieseler fluidity	F.S.I.
			Moisture-free basis					
204E	Coal blend	6.5	33.2	59.9	6.9	1.11	7.8	6
	Coke		1.4	89.2	9.4	0.81		
211E	Coal blend	6.3	32.6	60.4	7.0	1.15	4	5
	Coke		1.4	88.6	10.0	0.89		
218E	Coal blend	6.5	32.6	60.7	6.7	1.13	3	4
	Coke		1.5	88.6	9.9	0.88		
226E	Coal blend	6.8	32.5	60.8	6.7	1.13	3	4½
	Coke		1.1	89.8	9.1	0.84		
229E	Coal blend	5.4	31.9	61.5	6.6	1.11	2	3½
	Coke		1.3	89.0	9.7	0.84		

Table H. - Analytical Data for Coke Runs Shown in Table 10
(Summer Period)

Coal blend: 75% Illinois No. 6B
25% Pocahontas

Run		M.	V.M.	F.C.	Ash	Sulfur	Gieseler fluidity	F.S.I.
			Moisture-free basis					
203E	Coal blend	7.0	33.5	59.3	7.2	1.05	9	6
	Coke		1.3	88.3	10.4	0.78		
209E	Coal blend	6.5	32.9	60.0	7.1	1.04	6	5½
	Coke		1.4	88.5	10.1	0.80		
217E	Coal blend	5.6	32.2	60.8	7.0	1.02	3	4
	Coke		1.3	88.6	10.1	0.77		
225E	Coal blend	6.8	32.9	59.9	7.2	1.06	3	4½
	Coke		1.2	88.7	10.1	0.83		
228E	Coal blend	5.8	33.4	59.4	7.2	1.05	2	4
	Coke		1.4	88.6	10.0	0.83		
234E	Coal blend	4.7	32.4	60.6	7.0	1.05	1	3½
	Coke		1.2	88.5	10.3	0.79		

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114