### Burning Characteristics of Fuels

As a result of requests for information on the suitability of vaious fuels for domestic heating, laboratory apparatus was installed which permitted closely controlled tests of the burning characteristics of a wide variety of fuels. Based on a conventional cast-iron, sectional, hot-water boiler, this equipment permits measurements of the quantity of smoke produced, the rate of heat absorption, composition and temperature of the flue gas, pressure drop through the fuel bed, rate of burning, and efficiency. Equipped with a natural-draft chimney, mounted entirely inside the laboratory so that is is unaffected by winds or other variables, tests can be made in which the fuel itself determines its rate of burning. Automatic control equipment has been provided so that the rate of air supply can be varied in proportion to the demands of the burning fuel, or can be maintained at a fixed value. The provision of a special firing door containing protected windows allows inspection of the fire at any time or photographing the fuel bed without interference with the test. Either standard procedures or time-lapse motion pictures to accentuate actions occurring in the fuel bed are used. Tests have been made with this equipment of packaged fuel made from anthracite fines mixed with varying amounts of bituminous coal, of char made from high-volatile C bituminous coal, and of lignite briquets prepared experimentally from waste sizes of fuel.

### Stability and Structure of Burner Flames

The work described in last year's report on the structure and stability of flames has been published.69/ Further experiments were conducted on the air entrainment in Bunsen burners. Several series of data have been obtained by systematic changes of the gas flow, of the gas-orifice diameter, and of the length of the burner tube. The data are being analyzed and a series of experiments on Venturi-type burners now in progress will complete the investigation.

## CARBONIZATION AND GASIFICATION

Special studies were made of the carbonization properties of new low- and medium-volatile bituminous coals that might be used to increase the Nation's supply of coal of proved coking properties whose reserves are being rapidly depleted. Studies were also made of two Chile coals to assist the Chilean Government in establishing an iron-smelting industry.

### Small-Scale Laboratory Tests of Coking Coals

In connection with the Bureau of Mines-American Gas Association (BM-AGA) survey of gas- and coke-making properties of American coals, small-scale laboratory carbonization tests were made of coals from various States to determine their suitability for the production of coke. The tests included the

69/ Von Elbe, G., and Mentser, M., Further Studies of the Structure and Stability of Burner Flames: Jour. Chem. Phys., vol. 13, 1945, pp. 89-100.

the Fischer low-temperature carbonization assay, the United States Steel Corp. high-temperature distillation assay, and the Bureau of Mines agglutinating-value test. Coals tested were from the following sources: Washed coal from Hill bed, Hickey No. 1 mine, Fort Payne, Cherokee County, Ala.; No. 5 Block bed, No. 5 mine, Montcoal, Raleigh County, W. Va.; and Pocahontas No. 6 bed, Birdseye mine, Sewell, Fayette County, W. Va. In addition, high-temperature carbonization tests were made of a blast-furnace mix composed of 80 percent Fairmont- and 20 percent Beckley-bed coals and of a foundry-coke mix consisting of 53 percent Pittsburgh-bed coal, 43 percent Beckley-bed coal, and 4 percent No. 4 buckwheat-size anthracite. Results of small-scale laboratory carbonization tests of several coals have been incorporated in technical papers published or prepared for publication during the year. (See Exploration of Coal Deposits, p. 25 and Carbonization Properties of American Coals, p. 81).

Agglutinating-value tests were made of more than 120 diamond drill-core and mine samples of coal submitted in connection with projects for locating new sources of coking coal for steel plants and for proving coal reserves. The coals were from the following sources: Lookout Mountain field of northeastern Alabama and northwestern Georgia; Grand Mesa field near Paonia, Gunnison County, Colo.; Durango field in La Plata County, Colo.; Georges Creek field of western Maryland; Coaldale field in Esmeralda County, Nev.; Deep River field in Chatham County, N. C.; Northern field in Anderson County, Tenn.; and the New River field in West Virginia. Agglutinating values of drill-core samples from the Lookout Mountain field in Alabama ranged from 6.5 to 8.5 kilograms and those of mine samples from 0.7 to 7.0 kilograms. These agglutinating-value results, obtained at a 15:1 ratio of silicon carbide to coal, indicate that many of the coals are strongly coking. Low values for some of the mine samples are probably due to oxidation of the coal since some samples were collected from abandoned mines. The agglutinating values of Lookout Mountain coals of Georgia ranged from 4.8 to 8.7 kilograms, which are considered satisfactory for coking coal. The agglutinating values of the Georges Creek coals in Maryland ranged from 0.6 to 10.6 kilograms; the low values probably were due to oxidation of the coal. In Colorado, the La Plata County coals examined are probably fair-coking, and the Paonia coals range from nearly noncoking to fair-coking. The North Carolina, Tennessee, and West Virginia coals have agglutinating values that would classify them as fair- to good-coking.

Agglutinating values are an approximate measure of the extent of coal oxidation and therefore are of value in following the changes in the coking quality of coals during storage. In connection with a survey of storing quality of coals, the agglutinating values of 65 coal samples were determined during the year. The coals examined were from the following sources: Hill and Mary Lee beds of Alabama; Gunnison, La Plata, and Mesa Counties, Colo.; No. 5 and No. 6 beds of Illinois; No. 5 and No. 6 beds of Indiana; Elkhorn No. 3, Kentucky No. 11, and Kentucky No. 14 beds of Kentucky; Bevier and Walker beds of Missouri; Raton bed of New Mexico; No. 6 bed of Ohio; McAlester bed of Oklahoma; Pittsburgh bed of Pennsylvania; Roslyn No. 5 bed of Washington; Eagle, No. 5 Block, Pocahontas No. 3 and Pocahontas No. 6 beds of West Virginia; Finch bed of Wyoming; and Lota and Schwager areas of Chile.

The free-swelling index by the A.S.T.M. Tentative Method of Test for Free-Swelling Index of Coal was determined for 10 samples of coal from stripping operations in Bedford and Clinton Counties, Pa., and in Garrett County, Md., in connection with the potential use of these coals as railroad locomotive fuels. The results showed that some of the coals were nonswelling and nearly noncaking and hence would be unsatisfactory for locomotive use, since the "stack losses" would be high because of coal blown off the grates.

In connection with a survey of carbonizing properties of coals of Chile, made at the request of the Chilean Government, agglutinating-value tests were made of 17 samples of coals and coal blends from the Lota and the Schwager mining areas. The values at the 15:1 silicon carbide:coal ratio ranged from 1.7 to 5.5 kilograms and show that most of the coals examined are of only fair coking quality. One coal tested from the Province of Valdivia and two near the Straits of Magellan were noncoking.

Free-swelling indexes and agglutinating values were determined on 11 samples of coal from the Feng and Lung mines at Peipay near Chungking, Szechwan Province, China. These tests were made at the request of the Foreign Economic Administration, which is assisting the Chinese Government in the development of its coal resources. The agglutinating values ranged from 3.9 to 8.4 kilograms and the free-swelling indexes from 1.5 to over 9. The agglutinating values and free-swelling results show that some of the coals are strongly coking. The ash content of the coals on a dry-coal basis ranged from 10.7 to 32.6 percent. It is possible that their coking properties can be improved by removal of extraneous ash by coal-washing methods.

## Carbonizing Properties of American Coals

Studies on the carbonizing properties, plasticity, expansion, and oxidation of coal were continued. Coals received for complete series of tests by the BM-AGA method of determining gas-, coke-, and byproduct-making properties were: (1) Hill bed, Hickey mine, Fort Payne, Cherokee County, Ala.; (2) No. 5 Block bed, No. 5 mine, Montcoal, Raleigh County, W. Va.; (3) Pocahontas No. 6 bed, Birdseye mine, Sewell, Fayette County, W. Va.; (4) a 50:50 composite of No. 3 bed, San Jose mine, and of No. 5 bed, San Pedro Sur mine, in the Schwager area, Chile; and (5) a 4:45:25:25 composite of Alta bed (Pique Nuevo mine), Alta bed (Pique Grande mine), Chica bed (Pique Grande mine), and Arriba bed (Pique Grande mine), respectively, in the Lota mining area. The Alabama coal and the two West Virginia coals were studied as part of an established program to increase the supply of domestic coking coals. Schwager and Lota coals were tested to determine their suitability, singly or in blends, for the manufacture of metallurgical coke in Chile. Medium-volatile bituminous Hill-bed coal was tested both in the unwashed and washed condition. The contents of coke and sulfur on the as-carbonized basis were reduced by washing from 6.1 to 2.3 and from 0.9 to 0.5 percent, respectively. No. 5 Block coal ranked as high-volatile A bituminous and contained 3.3 percent ash and 0.8 percent sulfur. Medium-volatile bituminous Pocahontas No. 6 bed coal contained 13.9 percent ash and 1.0 percent sulfur and probably would have to be washed to compete with other high-rank coals used in blends carbonized commercially. The composites of Schwager coals and of Lota coals also ranked as high-volatile A bituminous but lower in that classification than No. 5 Block-bed coal. The dry, mineral-matter-free, fixed-carbon contents of these three samples were 54.0, 55.1, and 63.4 percent, respectively. The Schwager composite contained 7.2 percent ash and 1.2 percent sulfur, and the Lota composite contained 7.4 percent ash and 2.1 percent sulfur, on the as-carbonized basis. These Chilean coals are somewhat similar in chemical properties to the Utah coking coals of the United States.

Table 8 gives the yields of carbonization products obtained on the as-carbonized basis by the BM-AGA method at 900° C. in 18-inch retort tests on the coals and coal blends named. Medium-volatile bituminous Hill- and Pocahontas No. 6-bed coals gave characteristic low yields of volatile products and high yields of coke. As would be expected from their respective ranks, the high-volatile A bituminous No. 5 Block-bed coal yielded less coke and more gas, tar, light oil, and ammonia than the medium-volatile bituminous coals. The high-volatile A bituminous Schwager and Lota coals, being lower in rank than the No. 5 Block-bed coal, yielded considerably less coke and more gas. Yields of carbonization products from the various coal blends, whose compositions are given in table 8, differed from those of their constituent coals in accordance with changes in rank resulting from blending.

Table 9 shows the physical and chemical properties of the gas. The heating values of gas from Pocahontas No. 6 coals are low, both on the basis of B.t.u. per cubic foot and as B.t.u. per pound; however, low heating values are characteristics of the high-temperature gases from medium-volatile bituminous coals. No. 5 Block coal ranks as high-volatile A bituminous, but the yield of gas as B.t.u. per pound was only 2,990; coals of this rank usually yield 3,100 to 3,400 B.t.u. per pound. The Chilean coals were better gas coals, Schwager and Lota composites yielding 3,650 to 3,480 B.t.u. per pound, respectively. In blending, heating values in gas generally were lowered when the rank of coal was raised, and raised when the rank was lowered. The gases from Hill and Pocahontas No. 6 coals did not contain excessive proportions of hydrogen sulfide. Washing the Hill coal decreased the content of hydrogen sulfide from 280 to 140 grains per 100 cubic feet. Gases from Schwager and Lota coals contained 670 to 520 grains per 100 cubic feet, respectively.

Tables 10 and 11, respectively, show the physical properties of cokes from the domestic and Chilean coals. The shatter and tumbler indexes of the Hill coke were satisfactorily high; they were lowered by blending with Pittsburgh-bed coal from the Warden mine. The coke from the unwashed sample was more abradable than that from the washed sample. No. 5 Block coke resisted shattering more than the average coke from high-volatile A coals; its 1/4-inch tumbler index (66.7) was relatively low, indicating high abradability. Blending with 20 and 30 percent Pocahontas No. 3 coal improved this coke appreciably. Pocahontas No. 6 coke resisted shattering well but did not resist abrasion in tumbling; reduction of the ash content of this coal probably would lower the abradability of its coke. Blending with Pittsburgh coal raised the 1/4-inch tumbler index appreciably but lowered the 2- and 1-1/2-inch shatter indexes.

TABLE 8. - Yields of carbonization products, as-carbonized basis

Coal a87-100 percent Hill bed (unwashed)
Coal 87-100 percent Hill bed (washed)
Coal 87A-20 percent Hill bed (washed) and 80 percent Pittsburgh bed
Coal 87B-30 percent Hill bed (washed) and 70 percent Pittsburgh bed
Coal 88-100 percent No. 5 Block bed
Coal 88A-80 percent No. 5 Block bed and 20 percent Pocahontas No. 3 bed
Coal 88B-70 percent No. 5 Block bed and 30 percent Pocahontas No. 3 bed
Coal 89-100 percent Pocahontas No. 6 bed
Coal 89A-20 percent Pocahontas No. 6 bed and 80 percent Pittsburgh bed
Coal 89B-30 percent Pocahontas No. 6 bed and 70 percent Pittsburgh bed
Coal 228-100 percent Schwager composite
Coal 228A-90 percent Schwager composite (228) and 10 percent Pocahontas No. 3 bed
Coal 228B-90 percent Schwager composite (228) and 10 percent char
Coal 229-100 percent Lota composite
Coal 229A-90 percent Lota composite (229) and 10 percent Pocahontas No. 3 bed
Coal 229B-90 percent Lota composite (229) and 10 percent char

| | Yields, percent by weight of coal1/ | | | | | | | Yields per ton of coal1/ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Coal No. | Coke | Gas | Tar | Light oil | Free ammonia | Liquor | Total | Gas, cubic feet | Tar, gallons | Light oil, gallons in gas | $(NH_4)_2SO_4$, pounds |
| a87 | 78.5 | 10.4 | 3.1 | 0.58 | 0.180 | 5.6 | 98.4 | 9,750 | 6.3 | 1.63 | 17.2 |
| 87 | 79.3 | 10.9 | 3.2 | .61 | .180 | 5.5 | 99.7 | 10,300 | 6.7 | 1.71 | 20.8 |
| 87A | 71.3 | 13.8 | 6.5 | 1.01 | .154 | 6.1 | 98.9 | 10,250 | 13.7 | 2.83 | 24.4 |
| 87B | 72.3 | 13.7 | 6.3 | 1.03 | .144 | 5.9 | 99.4 | 10,400 | 13.2 | 2.87 | 22.6 |
| 88 | 71.4 | 13.9 | 6.2 | 1.20 | .131 | 6.1 | 98.9 | 10,100 | 12.6 | 3.30 | 20.2 |
| 88A | 74.0 | 13.4 | 5.0 | 1.03 | .145 | 5.6 | 99.2 | 10,100 | 10.0 | 2.81 | 21.4 |
| 88B | 75.3 | 13.0 | 4.6 | .94 | .149 | 5.6 | 99.6 | 9,950 | 9.6 | 2.59 | 21.1 |
| 89 | 80.5 | 10.7 | 2.5 | .61 | .112 | 4.9 | 99.3 | 9,450 | 4.9 | 1.65 | 15.9 |
| 89A | 71.8 | 13.9 | 6.2 | .98 | .142 | 5.6 | 98.6 | 10,150 | 12.8 | 2.69 | 20.8 |
| 89B | 72.9 | 13.5 | 5.6 | 1.05 | .133 | 5.9 | 99.1 | 10,150 | 11.6 | 2.88 | 21.7 |
| 228 | 62.9 | 18.6 | 6.7 | 1.38 | .086 | 8.0 | 97.7 | 11,250 | 14.1 | 3.79 | 20.0 |
| 228A2/ | 65.2 | 18.0 | 6.0 | 1.27 | .089 | 7.3 | 97.9 | 11,100 | 12.5 | 3.48 | 18.9 |
| 228B2/ | 64.5 | 18.5 | 6.0 | 1.25 | .072 | 7.5 | 97.8 | 11,150 | 12.6 | 3.44 | 19.4 |
| 2292/ | 62.7 | 19.3 | 5.9 | 1.37 | .112 | 8.5 | 97.9 | 11,450 | 12.3 | 3.76 | 21.5 |
| 229A | 64.5 | 18.3 | 5.5 | 1.26 | .105 | 8.1 | 97.8 | 11,300 | 11.4 | 3.44 | 20.2 |
| 229B | 64.0 | - | 5.4 | 1.31 | .124 | 8.0 | - | - | 11.1 | 3.57 | 21.8 |

1/ Coke, tar, ammonia, and light oil are reported moisture-free; gas is reported as stripped of light oil and saturated with water vapor at 60° F. and under a pressure of 30 inches of mercury.

2/ Coal crushed to minus 1/8-inch.

TABLE 9. - Physical and chemical properties of gas

Coal a87-100 percent Hill bed (unwashed)
Coal 87-100 percent Hill bed (washed)
Coal 87A-20 percent Hill bed (washed) and 80 percent Pittsburgh bed
Coal 87B-30 percent Hill bed (washed) and 70 percent Pittsburgh bed
Coal 88-100 percent No. 5 Block bed
Coal 88A-80 percent No. 5 Block bed and 20 percent Pocahontas No. 3 bed
Coal 88B-70 percent No. 5 Block bed and 30 percent Pocahontas No. 3 bed
Coal 89-100 percent Pocahontas No. 6 bed
Coal 89A-20 percent Pocahontas No. 6 bed and 80 percent Pittsburgh bed
Coal 89B-30 percent Pocahontas No. 6 bed and 70 percent Pittsburgh bed
Coal 228-100 percent Schwager composite
Coal 228A-90 percent Schwager composite (228) and 10 percent Pocahontas No. 3 bed
Coal 228B-90 percent Schwager composite (228) and 10 percent char
Coal 229-100 percent Lota composite
Coal 229A-90 percent Lota composite (229) and 10 percent Pocahontas No. 3 bed
Coal 229B-90 percent Lota composite (229) and 10 percent char

| Coal No. | Specific gravity | Gross heating value[1/]: B.t.u. per cubic foot, Determined | Gross heating value[1/]: B.t.u. per cubic foot, Calculated | Gross heating value[1/]: B.t.u. per pound of coal | $H_2S$ grains per 100 cubic feet | Composition, dry, percent by volume: $CO_2$ | Illuminants | $O_2$ | $H_2$ | CO | $CH_4$ | $C_2H_6$ | $N_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a87 | 0.282 | 524 | 524 | 2,550 | 280 | 1.4 | 2.0 | 0.4 | 64.4 | 3.2 | 26.8 | 0.6 | 1.2 |
| 87 | .280 | 526 | 523 | 2,710 | 140 | 1.1 | 1.6 | .4 | 65.4 | 3.1 | 26.9 | .7 | .8 |
| 87A | .356 | 584 | 579 | 2,990 | 330 | 1.6 | 3.6 | .4 | 55.6 | 5.5 | 30.8 | 1.3 | 1.2 |
| 87B | .351 | 580 | 575 | 3,020 | 280 | 1.4 | 3.6 | .5 | 56.0 | 5.4 | 30.3 | 1.3 | 1.5 |
| 88 | .364 | 592 | 581 | 2,990 | 290 | 2.1 | 4.0 | .4 | 53.7 | 6.2 | 32.7 | .2 | .7 |
| 88A | .350 | 570 | 576 | 2,880 | 260 | 1.9 | 3.9 | .4 | 55.2 | 5.2 | 31.9 | .3 | 1.2 |
| 88B | .347 | 575 | 573 | 2,860 | 240 | 1.6 | 3.9 | .3 | 56.8 | 4.8 | 29.9 | 1.1 | 1.6 |
| 89 | .301 | 528 | 529 | 2,490 | 320 | 1.4 | 2.3 | .4 | 63.3 | 3.5 | 27.5 | .4 | 1.2 |
| 89A | .363 | 590 | 586 | 2,990 | 350 | 1.9 | 4.0 | .3 | 54.5 | 5.5 | 31.8 | .9 | 1.1 |
| 89B | .353 | 581 | 579 | 2,950 | 350 | 1.7 | 3.7 | .4 | 55.5 | 5.4 | 31.2 | 1.0 | 1.1 |
| 228 | .438 | 649 | 627 | 3,650 | 670 | 3.6 | 6.3 | .4 | 45.3 | 8.2 | 33.5 | 1.5 | 1.2 |
| 228A[2/] | .431 | 626 | 613 | 3,470 | 590 | 3.4 | 5.9 | .3 | 47.4 | 7.8 | 32.9 | 1.1 | 1.2 |
| 228B[2/] | .440 | 622 | 618 | 3,470 | 590 | 3.7 | 5.8 | .3 | 46.0 | 8.1 | 32.7 | 1.8 | 1.6 |
| 229[2/] | .447 | 607 | 598 | 3,480 | 520 | 4.4 | 5.6 | .4 | 46.0 | 9.6 | 31.9 | 1.0 | 1.1 |
| 229A | .430 | 605 | 589 | 3,420 | 470 | 4.0 | 4.8 | .4 | 48.1 | 10.1 | 29.1 | 2.3 | 1.2 |
| 229B | - | - | - | - | - | - | - | - | - | - | - | - | - |

1/ Stripped of light oil and saturated with water vapor at 60° F. and under a pressure of 30 inches of mercury.
2/ Coal crushed to minus 1/8-inch.

TABLE 10. - Physical properties of coke (BM-AGA method)

Coal a87-100 percent Hill bed (unwashed)
Coal 87-100 percent Hill bed (washed)
Coal 87A-20 percent Hill bed (washed) and 80 percent Pittsburgh bed
Coal 87B-30 percent Hill bed (washed) and 70 percent Pittsburgh bed
Coal 88-100 percent No. 5 Block bed
Coal 88A-80 percent No. 5 Block bed and 20 percent Pocahontas No. 3 bed
Coal 88B-70 percent No. 5 Block bed and 30 percent Pocahontas No. 3 bed
Coal 89-100 percent Pocahontas No. 6 bed
Coal 89A-20 percent Pocahontas No. 6 bed and 80 percent Pittsburgh bed
Coal 89B-30 percent Pocahontas No. 6 bed and 70 percent Pittsburgh bed

| Coal No. | True specific gravity | Apparent specific gravity | Cells, percent | Shatter test, cumulative percent upon- | | | | Tumbler test, cumulative percent upon- | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2-inch screen | 1-1/2-inch screen | 1-inch screen | 1/4-inch screen | 2-inch screen | 1-1/2-inch screen | 1-inch screen | 1/4-inch screen |
| a87 | 1.90 | 0.82 | 56.9 | 60.5 | 81.4 | 95.1 | 98.4 | 15.0 | 42.4 | 66.4 | 74.6 |
| 87 | 1.86 | .82 | 55.9 | 56.6 | 81.7 | 96.6 | 98.9 | 12.6 | 45.0 | 70.9 | 77.3 |
| 87A | 1.89 | .85 | 55.0 | 47.4 | 79.9 | 94.6 | 98.5 | 3.0 | 32.9 | 64.6 | 74.8 |
| 87B | 1.88 | .85 | 54.8 | 40.5 | 77.1 | 94.9 | 99.0 | 3.7 | 30.2 | 65.5 | 76.8 |
| 88 | 1.96 | .89 | 54.6 | 49.5 | 74.0 | 89.3 | 97.6 | 1.5 | 18.9 | 46.8 | 66.7 |
| 88A | 1.90 | .89 | 53.2 | 56.1 | 79.5 | 92.2 | 98.1 | 4.7 | 25.6 | 53.3 | 71.1 |
| 88B | 1.91 | .89 | 53.4 | 65.8 | 83.1 | 93.4 | 98.3 | 6.7 | 31.0 | 55.7 | 71.6 |
| 89 | 1.93 | .94 | 51.3 | 80.7 | 91.0 | 95.2 | 98.4 | 19.1 | 44.6 | 56.4 | 65.8 |
| 89A | 1.92 | .88 | 54.2 | 47.9 | 77.6 | 92.7 | 97.9 | 3.9 | 24.0 | 56.2 | 70.8 |
| 89B | 1.91 | .88 | 53.9 | 57.7 | 81.1 | 93.6 | 97.9 | 6.5 | 30.6 | 56.1 | 70.1 |

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TABLE 11. - Physical properties of coke (Columbia Steel Co. methods)

Coal 228-100 percent Schwager composite
Coal 228A-90 percent Schwager composite (228) and 10 percent Pocahontas No. 3 bed
Coal 228B-90 percent Schwager composite (228) and 10 percent char
Coal 229-100 percent Lota composite
Coal 229A-90 percent Lota composite (229) and 10 percent Pocahontas No. 3 bed
Coal 229B-90 percent Lota composite (229) and 10 percent char

| Coal No. | True specific gravity | Apparent specific gravity | Cells percent | Shatter test, cumulative percent upon- 1-1/2-inch screen | 1-inch screen | 3/4-inch screen | 1/2-inch screen | Tumbler test, cumulative percent upon- 1-1/2-inch screen | 1-inch screen | 3/4-inch screen | 1/2-inch screen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 228 | 1.94 | 0.72 | 62.9 | 30 | 55 | 67 | 84 | 5 | 24 | 36 | 57 |
| 228A 1/ | 1.93 | .77 | 60.1 | 51 | 76 | 84 | 92 | 18 | 49 | 59 | 71 |
| 228B 1/ | 1.92 | .77 | 59.9 | 33 | 62 | 73 | 86 | 7 | 30 | 42 | 60 |
| 229 1/ | 1.94 | .75 | 61.4 | 36 | 67 | 75 | 86 | 4 | 33 | 45 | 58 |
| 229A | 1.95 | .78 | 60.0 | 48 | 79 | 87 | 93 | 14 | 55 | 64 | 72 |
| 229B | 1.94 | .76 | 60.8 | 34 | 65 | 75 | 87 | 5 | 35 | 46 | 58 |

1/ Coal crushed to minus 1/8-inch.

The cokes from Chilean coals were tested by methods developed by the Columbia Steel Co. for testing cokes made from Utah coals. These methods are less severe than BM-AGA methods. Results for both the shatter and tumbler tests generally are higher for Lota coke, indicating that it forms a stronger coke than Schwager coal, either singly or in blends with 10 percent Pocahontas No. 3 coal or with 10 percent low-temperature char. The average shatter and tumbler indexes for 900° C. cokes from three samples of Lower Sunnyside bed coal from the Columbia mine were, respectively, as follows: 1-1/2-inch, 30 and 6; 1-inch, 69 and 46; 3/4-inch, 82 and 65; and 1/2-inch, 93 and 78. Lota and Schwager coals, therefore, yielded weaker coke than was obtained from Lower Sunnyside coal when carbonized under identical conditions. Blending either of these Chilean coals with 10 percent Pocahontas No. 3 coal improved the physical properties of their cokes enough to make them somewhat stronger than the Sunnyside coke. The low-temperature char, which was made from Schwager coal, improved Schwager coke but had virtually no effect when blended in this same proportion (10 percent) on the strength of Lota coke.

Table 12 shows the analysis of the tar and light oil. The properties of the tars generally are normal for the carbonizing temperature and ranks of coal tested. The tar distillates from the Chilean coals contained higher proportions of neutral oils. Similar results were obtained from tests of Lower Sunnyside coal, which is of similar rank. The composition of light oil from Hill coal differed markedly from that of the light oils from the other coals, including Pocahontas No. 6, which is of similar rank. Hill coal light oil (from the washed sample) contained 53.3 percent benzene, whereas all others contained more than 70 percent. The proportions of the other three constituents, toluene, paraffins, and solvent naphtha, were higher in Hill coal light oil; this difference was especially large for solvent naphtha. However, Hill coal is not exceptional in this respect because other medium-volatile coals have yielded light oils low in benzene. The percentage composition of the 900° C. light oil from medium-volatile Bakerstown coal, for example, was benzene, 59.9; toluene, 24.6; paraffins, 4.0; and solvent naphtha, 11.5 percent.

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TABLE 12. - Analysis of tar distillate and light oil

Coal a87-100 percent Hill bed (unwashed)
Coal 87-100 percent Hill bed (washed)
Coal 87A-20 percent Hill bed (washed) and 80 percent Pittsburgh bed
Coal 87B-30 percent Hill bed (washed) and 70 percent Pittsburgh bed
Coal 88-100 percent No. 5 Block bed
Coal 88A-80 percent No. 5 Block bed and 20 percent Pocahontas No. 3 bed
Coal 88B-70 percent No. 5 Block bed and 30 percent Pocahontas No. 3 bed
Coal 89-100 percent Pocahontas No. 6 bed
Coal 89A-20 percent Pocahontas No. 6 bed and 80 percent Pittsburgh bed
Coal 89B-30 percent Pocahontas No. 6 bed and 70 percent Pittsburgh bed
Coal 228-100 percent Schwager composite
Coal 228A-90 percent Schwager composite (228) and 10 percent Pocahontas No. 3 bed
Coal 228B-90 percent Schwager composite (228) and 10 percent char
Coal 229-100 percent Lota composite
Coal 229A-90 percent Lota composite (229) and 10 percent Pocahontas No. 3 bed
Coal 229B-90 percent Lota composite (229) and 10 percent char

| Coal No. | Distillate, percent by volume of dry tar | | | Neutral tar oil, percent by volume | | | Refined light oil from gas, percent by volume | | | | Olefins in crude light oil from gas, percent by volume |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acids | Bases | Neutral oils | Olefins | Aromatics | Paraffins and naphthenes | Benzene | Toluene | Paraffins | Solvent naphtha | |
| a87 | 4.3 | 0.8 | 25.4 | 7.4 | 87.0 | 5.6 | 51.8 | 23.4 | 7.4 | 17.4 | 13.4 |
| 87 | 4.9 | 1.0 | 24.1 | 5.7 | 88.8 | 5.5 | 53.3 | 23.6 | 7.6 | 15.5 | 12.0 |
| 87A | 8.1 | 1.7 | 32.5 | 9.8 | 83.9 | 6.3 | 61.0 | 20.0 | 9.8 | 9.2 | 14.3 |
| 87B | 7.1 | 1.8 | 30.5 | 9.5 | 85.7 | 4.8 | 66.4 | 18.9 | 7.9 | 6.8 | 13.6 |
| 88 | 3.7 | 1.8 | 25.4 | 10.3 | 87.9 | 1.8 | 77.6 | 15.6 | 4.0 | 2.8 | 10.4 |
| 88A | 3.2 | 1.6 | 23.2 | 9.4 | 89.1 | 1.5 | 76.3 | 17.9 | 2.8 | 3.0 | 9.5 |
| 88B | 4.6 | 2.1 | 26.1 | 10.2 | 87.8 | 2.0 | 70.4 | 20.7 | 3.9 | 5.0 | 11.2 |
| 89 | 1.1 | 1.0 | 15.7 | 10.7 | 88.9 | .4 | 75.1 | 19.2 | 1.5 | 4.2 | 8.3 |
| 89A | 5.0 | 1.9 | 27.4 | 14.7 | 83.0 | 2.3 | 74.5 | 16.6 | 5.0 | 3.9 | 9.5 |
| 89B | 4.0 | 1.8 | 27.5 | 10.1 | 87.4 | 2.5 | 73.5 | 16.7 | 5.6 | 4.2 | 10.0 |
| 228 | 5.1 | 2.5 | 35.7 | 11.0 | 87.0 | 2.0 | 70.4 | 22.9 | 3.6 | 3.1 | 13.6 |
| 228A 1/ | 4.3 | 2.4 | 31.4 | 10.0 | 89.1 | .9 | 74.9 | 19.7 | 2.8 | 2.6 | 11.2 |
| 228B 1/ | 4.8 | 2.3 | 32.5 | 12.0 | 86.7 | 1.3 | 74.9 | 18.5 | 4.0 | 2.6 | 11.0 |
| 229 1/ | 4.8 | 2.7 | 32.5 | 14.0 | 84.9 | 1.1 | 76.7 | 19.4 | 1.8 | 2.1 | 12.2 |
| 229A | 4.6 | 2.4 | 32.0 | 13.0 | 86.6 | .4 | 74.2 | 20.6 | 2.2 | 3.0 | 10.8 |
| 229B | 4.4 | 2.6 | 32.3 | 12.0 | 87.6 | [illegible] | 75.5 | 19.4 | 2.5 | 2.6 | 10.4 |

1/ Coal crushed to minus 1/8-inch.

A report giving results of a study on the carbonizing properties of low-volatile bituminous Pocahontas No. 3-bed coal and of its 20:80 and 30:70 blends with Pittsburgh-bed, Warden mine, coal was published.70/ The investigations of the Pocahontas No. 3 coal included chemical analyses, agglutinating and plasticity tests, BM-AGA carbonization tests at 500°, 600°, 700°, 800°, 900°, and 1,000° C., determinations of oxidizing and expanding properties, and high- and low-temperature assay distillation tests. Oxidized samples of the coal were carbonized at 800° C., and the two blends with Pittsburgh-bed coal at 900° C. The Pocahontas No. 3 coal sample contained 5.2 percent ash and 0.7 percent sulfur on the as-carbonized basis, which are well below the limits specified for the production of metallurgical coke. As was expected because of its high rank, the coal gave an agglutinating value of 10.9 at a silicon carbide:coal ratio of 15:1, showed a low maximum Gieseler plastometer fluidity value of 2.7 dial divisions per minute at 481° C., and expanded strongly during carbonization. Yields of carbonization products in the 18-inch BM-AGA retort at 900° C. were: coke, 82.8 percent; and, on the basis of a ton of coal - gas 10,500 cubic feet; tar, 3.5 gallons; light oil in gas, 1.52 gallons; and ammonium sulfate, 11.6 pounds. The average charge density was 49.6 pounds per cubic foot, and the time of carbonization was 11.8 hours. The coke was blocky, fine-grained, and stable; the 1-1/2-inch shatter index was 81.2, and the 1- and 1/4-inch tumbler indexes were 64.4 and 74.5, respectively. The gas had a specific gravity of 0.280 and a determined heating value of 504 B.t.u. per cubic foot; the heating value of the gas per pound of coal was 2,650 B.t.u. The content of hydrogen sulfide was 90 grains per 100 cubic feet of gas. Blending the Pocahontas No. 3-bed with 70 and 80 percent Pittsburgh-bed coal increased the charge density to 49.9 pounds per cubic foot and decreased the carbonizing at 900° C. to 10.8 hours. The blends yielded less coke and more byproducts than were obtained from 100 percent Pocahontas No. 3 coal. Oxidation in air at 99.3° C. for 2.1 and 4.1 days had little effect on the quality of coke produced at 800° C.; oxidation for 8.0 days lowered the 1- and 1/4-inch tumbler indexes but did not affect the 1-1/2-inch shatter index; oxidation for 16.1 days virtually destroyed the coking property. Pocahontas No. 3 coal expanded enough to deform the BM-AGA retorts at all carbonizing temperatures except 500° C. It expanded 18.9 percent in the sole-heated oven at a charge density of 53.0 pounds per cubic foot, which is equivalent to 24.4 percent expansion at the charge density of 55.5 pounds per cubic foot used as a standard for comparison purposes.

A paper giving results of an investigation of the carbonizing properties and petrographic composition of Hazard No. 4 bed, Columbus No. 4 mine, Allais, Perry County, Ky., and of the high-temperature properties of Hazard No. 7 bed, Hardburly mine, Hardburly, Perry and Knott Counties, Ky., was published.71/ The high-volatile A bituminous Hazard No. 4 coal was carbonized

70/ Davis, J. D., Reynolds, D. A., Ode, W. H., and Holmes, C. R., Carbonizing Properties of Pocahontas No. 3-Bed Coal from Kimball, McDowell County, W. Va., and the Effect of Blending This Coal with Pittsburgh-Bed Coal: Bureau of Mines Tech. Paper 670, 1944, 35 pp.
71/ Davis, J. D., Reynolds, D. A., Ode, W. H., Holmes, C. R., Elder, J. L., and Wilson, J. E., Carbonizing Properties and Petrographic Composition of Hazard No. 4 Coal from Columbus No. 4 Mine, and High-Temperature Carbonizing Properties of Hazard No. 7 Coal from Hardburly Mine, Perry County, Ky.: Bureau of Mines Tech. Paper 672, 1945, 46 pp.