ALASKAN IC

# FUSIBILITY OF ASH OF UNITED STATES COALS



By Roy F. Abernehty and Elsie M. Cochrane



* * * * * * * * * * * information circular 7923

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

CONTENTS



TABLES



75

# FUSIBILITY OF ASH OF UNITED STATES COALS[1/]

by

Roy F. Abernethy[2/] and Elsie M. Cochrane[3/]

## INTRODUCTION

Laboratory determination of the fusibility of coal ash provides considerable information for the combustion engineer engaged in pulverized-coal firing and using underfeed and spreader stokers and hand-fired small industrial and domestic stokers. This information, and that obtained by trial tests, provides the essentials for procuring the best fuel for the particular installation. The continued increase in efficiently utilizing energy in coal has caused an increasing interest in the behavior of the ash or residue during combustion. This interest is shown not only in the larger electric generating plants but also in the domestic stokers, particularly the automatic types. Because there is considerable range in the fusibility of ash and there are various methods of combustion, it is not feasible to establish one set of specifications for coal based upon fusibility alone. The chemical and physical characteristics of the coal also must be considered for the best performance.

An earlier publication[4/] gave only the softening temperatures for mine samples and did not give the initial and fluid temperatures; therefore the fusibility intervals could not be determined. The intervals between the initial, softening, and fluid temperatures are, in many instances, more informative than the temperature at a deformation stage.

This publication includes all information on fusibility of coal-ash determinations of coal tested from 1921 to 1957. These data are, for the greater part, from tipple samples; the preceding publication contained information almost exclusively on mine samples. The data in this publication are of more

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1/ Work on manuscript completed August 15, 1958.

2/ Chief, Analysis Section, Branch of Bituminous Coal, Division of Solid Fuels Technology, Bureau of Mines, Region V, Pittsburgh, Pa.

3/ Statistical clerk, Analysis Section, Branch of Bituminous Coal, Division of Solid Fuels Technology, Bureau of Mines, Region V, Pittsburgh, Pa.

4/ Selvig, W. A., and Fieldner, A. C., Fusibility of Ash From Coals in the United States: Bureau of Mines Bull. 209, 1922, 119 pp.

practical value because the tipple samples5/ represent the coal as used; whereas the mine samples6/ were selected so that the coal was free of visual impurities.

This information should assist the consumer when procuring and utilizing coal.

## COAL ASH AND ITS ORIGIN

By definition,7/ coal ash is "inorganic residue remaining after ignition of combustible substances, determined by definite, prescribed methods."8/ The ash may not be the same in composition or quantity as the mineral matter in the coal.

The temperature employed in ignition of the combustible matter is high enough to decompose minerals such as carbonates, sulfides (pyrite), shales, and clay.

Mineral matter in coal is the composite product of (1) the mineral matter as a constituent of the vegetal matter from which the coal was formed, (2) substances absorbed by the carbonaceous material from percolating water or crystallized therefrom, (3) clays and minerals deposited simultaneously with the vegetal matter, and (4) adventitious contaminants from roof and floor during mining.

Compounds of silicon, aluminum, iron, calcium, and magnesium are the principal constituents, with lesser amounts of titanium, sodium, potassium, and sulfur. In certain areas minerals containing various other elements are found from trace amounts to quantities large enough for economic commercial recovery.

## METHOD OF ANALYSIS

Determination of the fusibility of ash is empirical; and factors such as rate of heating, atmosphere, and particle size of ash in test piece affect the results. Development of the method of analysis used to obtain the data in this report has been published.9/

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5/ Snyder, N. H., and Aresco, S. J., Coal Sampling (Revision of Tech. Paper 133): Bureau of Mines Handbook, 1957, 16 pp.

6/ Holmes, J. A., The Sampling of Coal in the Mine: Bureau of Mines Tech. Paper 1, 1918 (rev.), 22 pp.

7/ American Society for Testing Materials, Standard Definitions of Terms Relating to Coal and Coke (Designation D 121-30): ASTM Standards, 1954, p. 108.

8/ Fieldner, A. C., and Selvig, W. A., Methods of Analyzing Coal and Coke: Bureau of Mines Bull. 492, 1951, 51 pp.

9/ Fieldner, A. C., Hall, A. E., and Field, A. L., The Fusibility of Coal Ash and the Determination of the Softening Temperature: Bureau of Mines Bull. 129, 1918, 146 pp.

A detailed description of the method used to obtain the data in table 3 also has been published.10/

Coal ash ground to pass through a 74-micron (No. 200) sieve is molded into 3/4-inch-high triangular pyramids, referred to as cones. The side of the equilateral base is one-fourth inch. These cones are mounted vertically in a refractory base and heated in a natural gas-fired furnace at a rate between 5° and 10° C. per minute. The gas and air are adjusted to give the specified heating rate and also provide the required mildly reducing atmosphere around the cones. An optical pyrometer of the disappearing filament type was used in making the temperature measurements.

## FUSIBILITY OF ASH

The fusibility of ash should not be confused with such terms as "fusion," "softening," and "melting" points. It includes a temperature range and deformation record of a specially designed and prepared cone of the ash heated under specified conditions.

The fusibility of ash includes:

1. Initial Deformation Temperature. - The temperature at which the first rounding or bending of the apex of the cone occurs.

2. Softening Temperature. - The temperature at which the cone has fused down to a spherical lump.

3. Fluid Temperature. - The temperature at which the cone has spread out over the base in a flattened layer.

Temperatures at which the above deformations occur are used to compute three temperature intervals — the difference between condition 1 and 2, 1 and 3, and 2 and 3. These temperature intervals are used to estimate roughly the flow properties of the ash. For instance, if the temperature interval or fusibility range between the initial and fluid temperature is 40° to 50° F., the ash acts as a compound; but if this fusibility range is 300° to 500° F., the ash behaves as a mixture of compounds, one acting as a fluxing agent for a more refractory component.

Considerable information on the industrial application of the fusibility of the ash has been summarized.11/

The average softening temperatures, ranges of softening temperatures, and fusibility ranges (temperature interval between the initial and fluid temperatures) by beds and States are given in table 1.

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10/ Work cited in footnote 8.

11/ National Research Council, Chemistry of Coal Utilization: John Wiley & Sons, vol. 1, 1945, pp. 496-571.

## SOFTENING TEMPERATURE BY CLASS

In a previous publication[12] the softening temperature of coal ash from coals of the United States had been arbitrarily divided into three classes:

Class I. - Softening above 2,600° F.

Class II. - Softening between 2,200° and 2,600° F.

Class III. - Softening below 2,200° F.

The softening temperatures in table 2 have been classified by the foregoing scheme according to beds and States.

## SOURCE OF INFORMATION

The analyses tabulated in this paper were made in the Analysis Section, Bureau of Mines, Pittsburgh, Pa., and represent those made from June 1, 1921, to June 30, 1957. All analyses were reviewed for this report, and those used represent the sizes of the coals produced. If the analytical results of repeated samplings from a mine agreed, only the latest analyses were given; if results of samplings varied, all analyses were given to show the range that could be expected.

Bureau of Mines engineers collected the tipple samples and obtained from mine officials pertinent information, such as mine name, bed, location, and preparation of the coal. Mine samples were collected by engineers and geologists of the respective States and of the Federal Geological Survey and Bureau of Mines.

These data, collected over a period of 36 years, may include some duplications due to changes in the name of the mine. The values reported are correct for the samples analyzed but do not necessarily represent the average for the mine or present-day production.

## EXPLANATION OF TABLE 3

Column 1 lists alphabetically the State, county, town, and mine. The names of the coalbeds in column 2 are those accepted by the several State geologists. In some districts a local bed name may be used and therefore may be improperly correlated. The letters M and T in column 3 indicate mine and tipple samples, respectively. The size and preparation of each sample are shown in column 4. When more than one mine sample from the same mine was tested, the results were averaged. Columns 6, 7, and 8 give the initial, softening, and fluid temperatures, respectively.

12/ Work cited in footnote 4, p. 1.

TABLE 2. - Percentage distribution of softening temperatures by class (Con.)

| Region and state | Class 1 | Class 2 | Class 3 | Number of samples |
|---|---|---|---|---|
| | More than 2600 °F. | 2200 to 2600 °F. | Less than 2200 °F. | |
| 1 | 2 | 3 | 4 | 5 |
| **COAST** | | | | |
| Oregon | - | 40 | 60 | 10 |
| Washington | 32 | 65 | 3 | 182 |
| Region average | 30 | 64 | 6 | |
| Number of analyses for region | | | | 192 |
| **ALASKAN** | | | | |
| Alaska | 40 | 51 | 9 | 70 |
| Region average | 40 | 51 | 9 | |
| Number of analyses for region | | | | 70 |
| Average for United States | 26 | 44 | 30 | |
| Number of analyses in report | | | | 13,110 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] Valley Strip | | | [illegible] | | | | | | 2.5 | B17573 |
| Do. | do. | T | 5- by 1-1/2-inch | | 2,100 | 2,390 | 2,540 | 10.2 | 2.4 | B17574 |
| Jones & Pugh No. 1 | do. | T | 1-1/2-inch by 0 | | 2,680 | 2,730 | 2,840 | 12.0 | 2.0 | D62657 |
| Parrish | do. | T | Run-of-mine | | 2,210 | 2,680 | 2,780 | 16.3 | 2.4 | D[illegible] |
| Aldridge Shaft | Mary Lee | | | | | | | | | |
| Do. | | T | 6- by 3-inch | | 2,140 | 2,520 | 2,610 | 14.6 | 3.1 | D[illegible] |
| Do. | do. | T | 3-inch by 0 (W) | | 2,720 | 2,850 | 2,920+ | 15.7 | .6 | B17744 |
| Do. | do. | T | 6- by 3-inch | | 2,700 | 2,840 | 2,920+ | 15.7 | .7 | B17745 |
| Do. | do. | T | 3- by 1-1/2-inch (W) | | 2,790 | 2,870 | 2,910+ | 18.7 | .8 | C34754 |
| [illegible] | | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Do. | do. | M | | 5 | 2,770 | 2,820 | 2,910+ | 15.1 | .8 | C52300 to C52304 |
| Busby | America | T | 6- by 1-1/2-inch (W) | | 2,780 | 2,890 | 2,910+ | 12.1 | 1.6 | D73524 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,100 | 2,620 | 2,840 | 9.3 | 1.8 | D73525 |
| Lost Creek No. 1 | do. | T | Run-of-mine | | 2,540 | 2,690 | 2,810 | 18.2 | 2.0 | E55356 |
| New America | do. | T | 3- by 1-1/2-inch (W) | | 2,680 | 2,730 | 2,840 | 11.0 | 1.6 | C34827 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,680 | 2,730 | 2,840 | 12.2 | 1.6 | C34828 |
| Paynes Bend | | | | | | | | | | |
| Paynes Bend No. 1 | Pratt | M | | 5 | 2,450 | 2,530 | 2,600 | 6.9 | 1.5 | 87206 to 87210 |
| Prospect | | | | | | | | | | |
| Mammoth | Mary Lee | T | 7- by 2-inch | | 2,910+ | - | - | 13.2 | .7 | D71233 |
| Do. | do. | T | 5-inch by 0 | | 2,890 | 2,910+ | - | 13.4 | .8 | D71234 |
| Do. | do. | T | 4-inch by 0 | | 2,710 | 2,860 | 2,910+ | 11.9 | .7 | D84805 |
| Do. | do. | T | 7- by 2-inch | | 2,710 | 2,860 | 2,910+ | 12.2 | .7 | D84806 |
| Do. | do. | T | do. | | 2,740 | 2,860 | 2,910+ | 12.4 | .6 | D85376 |
| Do. | do. | T | 4-inch by 0 (W) | | 2,680 | 2,840 | 2,910+ | 12.1 | .6 | D85377 |
| Sipsey | | | | | | | | | | |
| Sipsey | Black Creek | M | | 4 | 2,200 | 2,470 | 2,600 | 3.6 | .9 | A57572 to A57575 |
| Sumiton | | | | | | | | | | |
| Drummond Hollow No. 4 | do. | T | 3-1/2-inch lump | | 2,680 | 2,760 | 2,890 | 1.6 | .6 | D47818 |
| Do. | do. | T | 3-1/2- by 1-1/4-inch | | 2,800 | 2,910+ | - | 1.7 | .6 | D47819 |
| Do. | do. | T | 1-1/4- by 1/2-inch (W) | | 2,750 | 2,800 | 2,890 | 2.9 | .6 | D47820 |
| Do. | do. | T | 1/2-inch by 0 | | 2,620 | 2,780 | 2,860 | 9.8 | .7 | D47821 |
| Prospect | Jefferson | M | | 1 | 2,110 | 2,200 | 2,510 | 4.5 | 2.4 | B94219 |
| Sumiton | Black Creek | T | 5-inch lump | | 2,210 | 2,380 | 2,640 | 1.8 | .7 | D47483 |
| Do. | do. | T | 5- by 3-inch | | 2,450 | 2,570 | 2,680 | 3.6 | .7 | D47484 |
| Do. | do. | T | 3- by 1-1/2-inch (W) | | 2,230 | 2,420 | 2,570 | 1.8 | .6 | D47485 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,260 | 2,540 | 2,680 | 2.7 | .7 | D47486 |
| Summit | do. | M | | 5 | 2,220 | 2,430 | 2,610 | 2.5 | .7 | A85876 to A85880 |
| Do. | do. | T | 3-inch lump | | 2,220 | 2,370 | 2,620 | 1.8 | .7 | A85882 |
| Do. | do. | T | 3- by 1-1/2-inch (W) | | 2,350 | 2,490 | 2,730 | 1.7 | .6 | A85883 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,230 | 2,480 | 2,620 | 2.5 | .7 | A85884 |
| Townley | | | | | | | | | | |
| Galloway No. 15 | Jagger | M | | 4 | 2,280 | 2,580 | 2,630 | 15.2 | 1.7 | 80119 to 80122 |
| Townley | do. | T | 5-inch lump | | 2,350 | 2,540 | 2,770 | 9.7 | 1.0 | B17575 |
| Do. | do. | T | 5- by 4-1/2-inch | | 2,390 | 2,580 | 2,790 | 11.4 | 1.3 | B17576 |
| Do. | do. | T | 4-1/2-inch by 0 (W) | | 2,590 | 2,700 | 2,810 | 12.5 | 1.3 | B17577 |
| Do. | Mary Lee | T | 4- by 1-1/2-inch | | 2,780 | 2,890 | 2,910+ | 12.7 | .7 | D40050 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,730 | 2,860 | 2,910+ | 12.3 | .8 | D40051 |
| Do. | Corona | T | 4- by 1-1/2-inch | | 2,150 | 2,180 | 2,520 | 8.5 | 3.9 | D44148 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,000 | 2,150 | 2,470 | 9.3 | 3.8 | D44149 |
| Townley No. 1 | Jagger | M | | 5 | 2,260 | 2,410 | 2,540 | 14.3 | 1.5 | A21139 to A21143 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| <u>Northern Alaska Region</u> | | | | | | | | | | |
| Ikpikpuk River | | | | | | | | | | |
| Outcrop | - | M | | 2 | 2,380 | 2,510 | 2,640 | 13.9 | .5 | A6847 and A6849 |
| Kiana | | | | | | | | | | |
| - | - | M | | 1 | 2,360 | 2,560 | 2,830 | 20.5 | .5 | A52083 |
| Killik River | | | | | | | | | | |
| Outcrop | - | M | | 1 | 2,290 | 2,340 | 2,360 | 14.1 | .3 | A6848 |
| Kukpowruk | | | | | | | | | | |
| Outcrop | - | M | | 3 | 2,340 | 2,420 | 2,670 | 4.9 | .1 | C61130 to C61132 |
| Meade River | | | | | | | | | | |
| Meade River Prospect | - | M | | 2 | 2,140 | 2,210 | 2,420 | 4.6 | .7 | C27944 and C27945 |

1/ M, mine sample; T, tipple sample. 2/ W, washed.

TABLE 3. - Fusibility of ash of United States Coals (Con.)

| State, county, town, and mine | Bed | Kind of sample[1/] | Size of coal[2/] | Number of samples averaged | Fusibility of Ash: Initial deformation temperature, ° F. | Fusibility of Ash: Softening temperature, ° F. | Fusibility of Ash: Fluid temperature, ° F. | Percent, dry basis: Ash | Percent, dry basis: Sulfur | Laboratory No. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| ALASKA (Con.) | | | | | | | | | | |
| Northern Alaska Region (Con.) | | | | | | | | | | |
| Peard Bay | | | | | | | | | | |
| Peard Bay Outcrop | - | M | | 1 | 2,460 | 2,570 | 2,850 | 12.0 | .4 | C27946 |
| Prospect Kugrua Inlet | - | M | | 1 | 2,470 | 2,570 | 2,840 | 7.7 | .7 | C27948 |
| Point Lay | | | | | | | | | | |
| Prospect Tepsako River | - | M | | 1 | 2,300 | 2,430 | 2,470 | 3.1 | .4 | C61139 |
| Wainwright | | | | | | | | | | |
| Kuk River No. 1 | - | T | Run-of-mine | | 2,050 | 2,140 | 2,810 | 2.7 | .3 | C61137 |
| Kuk River No. 2 | - | M | | 2 | 2,450 | 2,570 | 2,780 | 2.9 | .4 | C61133 and C61134 |
| Kuk River No. 3 | - | M | | 1 | 2,080 | 2,200 | 2,650 | 3.1 | .3 | C61135 |
| Kuk River Outcrop | - (Bottom) | M | | 1 | 2,150 | 2,190 | 2,290 | 3.7 | .4 | C27947 |
| Do. | - (Top) | M | | 1 | 2,230 | 2,590 | 2,670 | 4.4 | .5 | C27949 |
| Jarvis Creek Field | | | | | | | | | | |
| Gerstle River District | | | | | | | | | | |
| Outcrop S.E. of Donnely | A | M | | 1 | 2,580 | 2,660 | 2,710 | 13.0 | .3 | C71481 |
| Yukon Region | | | | | | | | | | |
| Broad Pass Field | | | | | | | | | | |
| Broad Pass | | | | | | | | | | |
| Prospect | - | M | | 2 | 2,320 | 2,370 | 2,560 | 19.7 | .3 | D94465 and D94466 |
| Colorado Station | | | | | | | | | | |
| Colorado Station | - | T | Run-of-mine | | 2,800 | 2,860 | 2,910+ | 17.6 | .5 | D93273 |
| Costello Creek | Dunkle | M | | 2 | 2,430 | 2,470 | 2,660 | 9.3 | .7 | C1804 and C1806 |
| Do. | Stevens | M | | 1 | 2,020 | 2,090 | 2,480 | 7.6 | .6 | C1805 |
| Do. | Billie | M | | 1 | 2,480 | 2,520 | 2,800 | 9.3 | .6 | C1807 |
| Do. | - | M | | 1 | 2,680 | 2,730 | 2,840 | 15.6 | .6 | D90444 |
| Do. | - | M | | 1 | 2,450 | 2,490 | 2,590 | 9.0 | .4 | D93272 |
| Dunkle Camp Creek | No. 8 | M | | 1 | 2,180 | 2,220 | 2,440 | 8.5 | .7 | B67785 |
| Galena | | | | | | | | | | |
| Galena Outcrop | - | M | | 1 | 2,290 | 2,370 | 2,640 | 2.8 | .4 | C36293 |
| Kaltag | | | | | | | | | | |
| Adolph Muller | - | M | | 1 | 2,910+ | - | - | 23.1 | .5 | A15869 |
| Kaltag Prospect | - | M | | 1 | 2,680 | 2,740 | 2,910 | 9.5 | .4 | C36295 |
| Mt. McKinley National Park | | | | | | | | | | |
| Alaska Road Commission | - | M | | 1 | 2,060 | 2,230 | 2,520 | 7.3 | .6 | B16186 |
| Prospect | - | M | | 1 | 2,150 | 2,240 | 2,340 | 9.6 | .3 | 94109 |
| Nenana Field | | | | | | | | | | |
| Healy Fork | | | | | | | | | | |
| Arctic Coal Co. | Basal | M | | 1 | 2,360 | 2,400 | 2,440 | 13.4 | .5 | E44121 |
| Do. | do. | T | Run-of-mine | | 2,200 | 2,260 | 2,490 | 8.6 | .3 | E63869 |
| Cripple Creek | No. 1 | M | | 3 | 2,250 | 2,350 | 2,450 | 11.5 | .3 | D64036 to D64038 |
| Do. | do. | T | Run-of-mine | | 2,500 | 2,550 | 2,730 | 12.4 | .2 | D77713 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Arctic Coal Co. | Basal | M | | 1 | 2,360 | 2,400 | 2,440 | 13.4 | .5 | E44[illegible] |
| Do. | do. | T | Run-of-m | | 2,200 | 2,260 | 2,490 | 8.6 | .3 | E63869 |
| Cripple Creek | No. 1 | M | | 3 | 2,250 | 2,350 | 2,450 | 11.5 | .3 | D64036 to D64038 |
| Do. | do. | T | Run-of-mine | | 2,500 | 2,550 | 2,730 | 12.4 | .2 | D77713 |
| Diamond | - | M | | 1 | 2,190 | 2,260 | 2,320 | 8.0 | .3 | C83485 |
| Diamond Coal Co. | - | M | | 2 | 2,250 | 2,420 | 2,480 | 9.2 | .4 | D4909 and D4910 |
| Healy Creek | - | M | | 2 | 2,290 | 2,360 | 2,480 | 12.5 | .4 | D4907 and D4908 |
| Outcrop | No. 6 | M | | 2 | 2,190 | 2,260 | 2,490 | 17.8 | .3 | C30893 and C30894 |
| Do. | No. 3 | M | | 1 | 2,420 | 2,470 | 2,510 | 6.2 | .2 | C30892 |
| Do. | do. | M | | 1 | 2,520 | 2,560 | 2,610 | 5.5 | .1 | C30895 |
| Roth-Taylor | Mammoth | M | | 1 | 2,370 | 2,410 | 2,430 | 4.6 | .1 | A11088 |
| Usibelli | No. 1 | T | 6- by 2-inch | | 2,450 | 2,490 | 2,700 | 10.9 | .2 | D77711 |
| Do. | do. | T | 2-inch by 0 | | 2,330 | 2,390 | 2,620 | 9.7 | .2 | D77712 |
| Do. | do. | T | Run-of-mine | | 2,100 | 2,180 | 2,420 | 7.6 | .2 | E65840 |
| Do. | do. | T | 2- by 5/8-inch | | 2,100 | 2,190 | 2,340 | 7.6 | .2 | E65841 |
| Do. | do. | T | Run-of-mine | | 2,120 | 2,330 | 2,510 | 9.1 | .3 | E65842 |
| Do. | do. | T | 6- by 2-inch | | 2,130 | 2,270 | 2,460 | 10.1 | .3 | E65843 |
| Do. | do. | T | Run-of-mine | | 2,190 | 2,360 | 2,520 | 9.6 | .2 | E65844 |
| Lignite Creek | | | | | | | | | | |
| Nulato Prospect | - | M | | 1 | 2,230 | 2,360 | 2,760 | 5.0 | .9 | C36294 |
| Lignite | | | | | | | | | | |
| Outcrop Teklanika River | No. 3 | M | | 1 | 2,340 | 2,380 | 2,470 | 13.5 | .4 | C64415 |
| Do. | No. 4 | M | | 1 | 2,110 | 2,160 | 2,260 | 8.0 | .3 | C64416 |
| Outcrop Santuary River | Upper | M | | 1 | 2,420 | 2,460 | 2,520 | 18.5 | .4 | C64417 |
| Do. | Lower | M | | 1 | 2,470 | 2,510 | 2,560 | 19.1 | .4 | C64418 |
| Outcrop Susnana River | - | M | | 1 | 2,130 | 2,190 | 2,290 | 8.2 | .3 | C64419 |
| Outcrop Savage River | Top | M | | 1 | 2,380 | 2,440 | 2,470 | 19.6 | .4 | C64420 |
| Outcrop Savage River | Middle | M | | 1 | 2,390 | 2,420 | 2,470 | 20.0 | .4 | C64421 |
| Do. | Lower | M | | 1 | 2,480 | 2,540 | 2,580 | 10.2 | .3 | C64422 |
| Do. | - | M | | 1 | 2,820 | 2,910+ | - | 22.3 | .5 | C64423 |
| Do. | - | M | | 1 | 2,510 | 2,570 | 2,620 | 5.9 | .2 | C64424 |
| Do. | - | M | | 1 | 2,470 | 2,520 | 2,580 | 18.4 | .6 | C64425 |
| McKinley | | | | | | | | | | |
| Outcrop Sable Pass | - | M | | 1 | 2,260 | 2,300 | 2,380 | 13.6 | .5 | C64413 |
| Outcrop Toklat River | - | M | | 1 | 2,410 | 2,470 | 2,520 | 9.9 | .6 | C64414 |
| Suntrana | | | | | | | | | | |
| Suntrana New | "B" | M | | 1 | 2,130 | 2,180 | 2,230 | 6.8 | .3 | C9526 |
| Do. | "C" | M | | 1 | 2,380 | 2,430 | 2,580 | 15.8 | .3 | C9525 |
| Do. | "D" | M | | 1 | 2,360 | 2,400 | 2,710 | 16.5 | .4 | C9530 |
| Do. | "E" | M | | 1 | 2,250 | 2,300 | 2,500 | 13.8 | .5 | C9524 |
| Do. | "F" | M | | 1 | 2,280 | 2,350 | 2,530 | 12.0 | .3 | C9527 |
| Suntrana Old | No. 3 | M | | 1 | 2,180 | 2,370 | 2,440 | 7.2 | .2 | B67589 |
| Do. | do. | M | | 3 | 2,340 | 2,390 | 2,510 | 6.3 | .2 | B80608 to B80610 |
| Do. | No. 4 | M | | 1 | 2,130 | 2,160 | 2,370 | 11.6 | .2 | C9528 |
| Do. | No. 6 | M | | 1 | 2,180 | 2,270 | 2,400 | 9.2 | .1 | C9529 |
| Unalakleet | | | | | | | | | | |
| Unalaklett | - | M | | 1 | 2,060 | 2,140 | 2,180 | 8.2 | .5 | B64867 |
| Do. | - | M | | 1 | 2,090 | 2,160 | 2,480 | 4.7 | .4 | C36296 |
| <u>Kuskokwim Region</u> | | | | | | | | | | |
| Nelson Island | | | | | | | | | | |
| Nelson Island | - | M | | 4 | 2,400 | 2,500 | 2,680 | 23.0 | .5 | C29496 to C29499 |
| <u>Cook Inlet Region</u> | | | | | | | | | | |
| Cook Inlet Field | | | | | | | | | | |
| Bluff Point | | | | | | | | | | |
| Bluff Point | Cooper | M | | 3 | 1,950 | 1,970 | 2,030 | 11.8 | .4 | 81606 to 81608 |
| Homer | | | | | | | | | | |
| Homer Coal Corp. | do. | M | | 1 | 2,780 | 2,840 | 2,910+ | 14.5 | .5 | C61783 |
| Do. | - | M | | 2 | 2,040 | 2,090 | 2,280 | 21.5 | .4 | C61954 and C61955 |
| Outcrop | - | M | | 1 | 2,380 | 2,410 | 2,440 | 4.5 | .2 | C83515 |

1/ M, mine sample; T tipple sample. 2/ W, washed.

| State, county, town, and mine | Bed | Kind of sample[1/] | Size of coal[2/] | Number of samples averaged | Fusibility of Ash: Initial deformation temperature, ° F. | Fusibility of Ash: Softening temperature, ° F. | Fusibility of Ash: Fluid temperature, ° F. | Percent, dry basis: Ash | Percent, dry basis: Sulfur | Laboratory No. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **ALASKA (Con.)** | | | | | | | | | | |
| Cook Inlet Region (Con.) | | | | | | | | | | |
| Matanuska Field | | | | | | | | | | |
| Anthracite Ridge | | | | | | | | | | |
| Prospect | No. 2 | M | | 1 | 2,250 | 2,330 | 2,420 | 6.5 | .6 | A3538 |
| Do. | No. 3 | M | | 1 | 2,230 | 2,280 | 2,330 | 4.2 | .3 | A3539 |
| Do. | No. 4 | M | | 1 | 2,240 | 2,320 | 2,680 | 6.5 | .6 | A3540 |
| Chickaloon | | | | | | | | | | |
| Chickaloon | No. 1 | M | | 2 | 2,720 | 2,830 | 2,880 | 16.2 | .7 | 83981 and 83982 |
| Do. | No. 3 | M | | 1 | 2,150 | 2,450 | 2,570 | 14.2 | .6 | 83174 |
| Do. | do. | M | | 3 | 2,060 | 2,270 | 2,370 | 12.5 | .7 | 85745 to 85747 |
| Do. | do. | M | | 2 | 1,960 | 2,100 | 2,220 | 9.9 | .7 | 85283 and 85284 |
| Do. | No. 4 | M | | 1 | 2,660 | 2,830 | 2,880 | 27.8 | .5 | 83983 |
| Do. | No. 5 | M | | 1 | 2,740 | 2,850 | 2,900 | 30.1 | .5 | 83173 |
| Do. | do. | M | | 5 | 2,430 | 2,600 | 2,700 | 16.6 | .6 | 85749 to 85753 |
| Do. | No. 6 | M | | 1 | 2,240 | 2,340 | 2,390 | 10.1 | .8 | 85285 |
| Do. | No. 8 | M | | 4 | 2,200 | 2,410 | 2,580 | 17.4 | .6 | 85740 to 85743 |
| Do. | No. 10 | M | | 1 | 2,200 | 2,280 | 2,390 | 12.5 | .7 | 83984 |
| Do. | do. | M | | 1 | 2,740 | 2,850 | 2,900 | 24.0 | .6 | 85755 |
| Coal Creek | Bardin | M | | 1 | 2,720 | 2,830 | 2,880 | 23.3 | .8 | 85282 |
| Do. | North Spalding | M | | 1 | 2,340 | 2,450 | 2,570 | 5.9 | .6 | 83985 |
| Do. | do. | M | | 2 | 2,130 | 2,360 | 2,430 | 16.8 | .6 | 85277 and 85278 |
| Do. | do. | M | | 2 | 2,040 | 2,140 | 2,210 | 9.0 | .5 | 85279 and 85280 |
| Do. | do. | M | | 1 | 2,390 | 2,740 | - | 16.5 | .4 | 80607 |
| Do. | North Tierney | M | | 2 | 2,440 | 2,580 | 2,640 | 9.6 | .6 | 83986 and 83987 |
| Do. | Olson | M | | 1 | 2,440 | 2,620 | 2,740 | 17.7 | .6 | 85640 |
| Eska | | | | | | | | | | |
| Eska | Upper Shaw | M | | 1 | 2,400 | 2,570 | 2,890 | 11.3 | .5 | B67588 |
| Do. | - | M | | 1 | 2,040 | 2,070 | 2,260 | 11.6 | .4 | C61784 |
| Mrak | - | M | | 1 | 2,870 | 2,910+ | - | 14.2 | .9 | E1851 |
| Do. | No. 4 | T | 2-1/4-inch by 0 | | 2,660 | 2,790 | 2,910+ | 16.9 | .4 | E69152 |
| Houston | | | | | | | | | | |
| Houston | - | M | | 2 | 2,430 | 2,540 | 2,690 | 19.0 | .4 | D3088 and D3089 |
| Jonesville | | | | | | | | | | |
| Evan Jones | No. 00 | M | | 1 | 2,050 | 2,310 | 2,470 | 22.5 | .5 | A11087 |
| Do. | No. 0 | M | | 1 | 2,720 | 2,740 | 2,800 | 24.5 | .4 | A11083 |
| Do. | No. 3 | M | | 1 | 2,400 | 2,580 | 2,680 | 19.7 | .3 | A11084 |
| Do. | No. 5 | M | | 1 | 2,150 | 2,370 | 2,460 | 22.1 | .3 | A11086 |
| Do. | No. 6 | M | | 1 | 2,680 | 2,740 | - | 15.6 | .3 | A11085 |
| Do. | No. 8 | M | | 1 | 2,960+ | - | - | 19.8 | .5 | A98201 |
| Do. | do. | M | | 2 | 2,650 | 2,790 | 2,920+(1)<br>2,830 (1) | 16.4 | .5 | B25076 and B25077 |
| Do. | do. | M | | 1 | 2,910+ | - | - | 19.1 | .3 | B56286 |
| Do. | No. 10 | M | | 1 | 2,910+ | - | - | 22.8 | .4 | B56287 |
| Do. | No. 3 | T | 3- by 1-1/2-inch (W) | | 2,450 | 2,490 | 2,700 | 27.1 | .2 | D92251 |
| Do. | do. | T | 1-1/2-inch by 0 (W) | | 2,520 | 2,600 | 2,780 | 22.6 | .2 | D92252 |
| Do. | do. | T | do. | | 2,680 | 2,750 | 2,890 | 16.6 | .2 | D92253 |
| Do. | No. 5 | T | 3- by 1-1/2-inch (W) | | 2,910+ | - | - | 21.3 | .1 | D92256 |
| | | | | | | | | 19.7 | .3 | D92257 |
| | | | | | 2,910+ | - | - | 17.9 | .2 | D92258 |
| | do. | T | 1-1/2-inch by 0 (W) | | 2,890 | 2,910+ | - | 14.2 | .3 | E128 |
| Do. | do. | T | do. | 1 | 2,840 | 2,910+ | - | 8.6 | .3 | E129 |
| Do. | No. 6 | M | | 1 | 2,440 | 2,610 | 2,810 | 9.1 | .3 | E130 |
| Do. | No. 7 | M | | 1 | 2,780 | 2,850 | 2,910+ | | | |
| Do. | No. 7A | M | | | | | | 7.5 | .3 | 85511 to 85513 |
| Do. | | | | 3 | 2,140 | 2,200 | 2,250 | 13.0 | .5 | B98926 |
| Moose Creek (Station) | [illegible] | M | | 1 | 2,720 | 2,800 | 2,910+ | 6.9 | .4 | B98927 and B98928 |
| | | | | | | | 2,910+(1) | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | do. | T | 1-1/2-inch by 0 (W) | | 2,910+ | - | - | 19.7 | .3 | D92257 |
| Do. | do. | T | do. | | 2,890 | 2,910+ | - | 17.9 | .2 | D92258 |
| Do. | No. 6 | M | | 1 | 2,840 | 2,910+ | - | 14.2 | .3 | E128 |
| Do. | No. 7 | M | | 1 | 2,440 | 2,610 | 2,810 | 8.6 | .3 | E129 |
| Do. | No. 7A | M | | 1 | 2,780 | 2,850 | 2,910+ | 9.1 | .3 | E130 |
| Moose Creek (Station) | | | | | | | | | | |
| Baxter | "Big" | M | | 3 | 2,140 | 2,200 | 2,250 | 7.5 | .3 | 85511 to 85513 |
| Buffalo | No. 1 | M | | 1 | 2,720 | 2,800 | 2,910+ | 13.0 | .5 | B98926 |
| Do. | No. 2 | M | | 2 | 2,630 | 2,730 | 2,910+(1)<br>2,860 (1) | 6.9 | .4 | B98927 and B98928 |
| Do. | No. 3 | M | | 2 | 2,880+(1)<br>2,640 (1) | -<br>2,710 (1) | -<br>2,880 (1) | 5.7 | .4 | B98929 and B98930 |
| Do. | No. 4 | M | | 1 | 2,310 | 2,340 | 2,660 | 5.8 | .3 | B98931 |
| Do. | No. 5 | M | | 3 | 2,700 | 2,770 | 2,870 | 23.6 | .3 | B98932 to B98934 |
| Do. | No. 6 | M | | 1 | 2,860 | 2,910+ | - | 35.4 | .3 | B98935 |
| Do. | No. 7 (Lower Bench) | M | | 1 | 2,910+ | - | - | 12.9 | .3 | B98936 |
| Do. | No. 7 (Upper Bench) | M | | 1 | 2,910+ | - | - | 28.1 | .3 | B98937 |
| LeRoy | No. 3 | M | | 1 | 2,450 | 2,510 | 2,530 | 10.0 | .2 | A1963 |
| Do. | No. 4 | M | | 1 | 2,560 | 2,580 | 2,590 | 15.8 | .2 | A1964 |
| Do. | No. 5 | M | | 1 | 2,340 | 2,510 | 2,530 | 20.1 | 1.1 | A1965 |
| Premier | - | M | | 1 | 2,800 | 2,910 | 2,960 | 6.7 | .3 | A1962 |
| Prospect on Moose Creek | - | M | | 3 | 2,910+(1)<br>2,710 (2) | 2,910+(1)<br>2,760 (1) | -<br>2,880 (1) | 13.1 | .3 | C31928 to C31930 |
| Palmer | | | | | | | | | | |
| Pioneer | - | T | 1-1/2-inch by 0 | | 2,540 | 2,650 | 2,750 | 13.3 | .4 | E43386 |
| Wasilla | | | | | | | | | | |
| Houston Coal Company | - (Upper Bench) | M | | 1 | 2,210 | 2,360 | 2,420 | 11.5 | .5 | D51894 |
| Do. | - (Lower Bench) | M | | 1 | 2,210 | 2,520 | 2,680 | 16.3 | .5 | D51895 |
| Southeastern Alaska Region | | | | | | | | | | |
| Admirality Island | | | | | | | | | | |
| Harkrader | - | M | | 2 | 2,170 | 2,260 | 2,450 | 23.4 | 1.2 | A43506 and A43507 |

## ARIZONA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Apache County | | | | | | | | | | |
| Chinle | | | | | | | | | | |
| Chinle | No. 1 | T | Run-of-mine | | 2,410 | 2,510 | 2,710 | 18.0 | 2.6 | B62406 |
| Salina | | | | | | | | | | |
| Salina | - | T | 2-inch lump | | 2,780 | 2,810 | 2,910+ | 22.7 | 1.4 | D95572 |
| Do. | - | T | 2-inch by 0 | | 2,790 | 2,840 | 2,910+ | 25.2 | 1.7 | D95573 |
| Salina Springs | | | | | | | | | | |
| Chinle No. 2 | "M" | M | | 2 | 2,740 | 2,860 | 2,910+ | 15.4 | 1.1 | E8897 and E8898 |
| Steam Boat - Trading Post (Outcrop) | "K" | M | | 1 | 2,390 | 2,570 | 2,790 | 22.8 | 1.0 | E8900 |
| Coconino County | | | | | | | | | | |
| Tuba City | | | | | | | | | | |
| Tuba City | - | M | | 2 | 2,500 | 2,590 | 2,660 | 12.6 | 2.2 | A51522 and A51523 |
| Tuba City No. 1 | No. 1 | T | Run-of-mine | | 2,760 | 2,820 | 2,910+ | 18.5 | 1.8 | B61477 |
| Navajo County | | | | | | | | | | |
| Holbrook | | | | | | | | | | |
| Prehistoric Indian | - | M | | 1 | 2,740 | 2,800 | 2,870 | 28.5 | 1.0 | B32871 |
| Do. | Lower | M | | 1 | 2,820 | 2,860 | 2,890 | 22.9 | .7 | B32872 |
| Do. | Upper | M | | 1 | 2,280 | 2,340 | 2,730 | 37.0 | 1.0 | B32873 |
| Kayenta | | | | | | | | | | |
| Kayenta | - | M | | 2 | 2,080 | 2,150 | 2,320 | 4.3 | .9 | A51525 and A51526 |
| Do. | No. 1 | T | Run-of-mine | | 2,210 | 2,270 | 2,480 | 6.1 | .5 | B61478 |

1/ M, mine sample; T, tipple sample    2/ W, washed.