Canada
Department of Mines and Resources
MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH
BUREAU OF MINES -- DIVISION OF FUELS

PHYSICAL AND CHEMICAL SURVEY
OF COALS FROM CANADIAN COLLIERIES
(Number Five)

–ALBERTA–

DRUMHELLER COALFIELD

Memorandum Series
No. 97
December, 1947

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Drumheller Coalfield

by

E. Swartzman and J.H.H. Nicolls

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FOREWORD

This report on subbituminous coals from the Drumheller coalfield in Alberta is the fifth in the series of publications on the "Physical and Chemical Survey of Coals from Canadian Collieries". The present report is the first of this series dealing with coals from the western coalfields, ranging in rank from bituminous to lignite, the earlier reports having been concerned with bituminous coals only, and from the Maritime Provinces.

In general the survey has been conducted in a manner to yield such basic data on the physical, physico-chemical, and chemical characteristics that would be useful to the operator in mining and preparation, and that could also be used in comparing the various coals in the same field and with coals in other fields. In particular the survey was conducted to ascertain to what extent an improvement in grade might be effected by sizing, crushing, washing and blending.

Although the survey of coals from the Drumheller area, has been quite comprehensive and has included all the main operating seams in the Drumheller, Rosedale, and East Coulee sub-districts, the coals from thirteen mines only were studied. These, however, were the typical larger operations which accounted for approximately seventy-five per cent of the total output of the area. The samples were collected during 1944, 1945 and 1946, and on completion of the study of the sample from each mine a preliminary report was prepared for limited distribution to the interested parties. The present report comprises the results of the investigations on the coals from the thirteen collieries, operating on four seams, together with a comparison of the characteristics of the coals.

The physical and chemical tests were conducted by the staff of the Fuel Research Laboratories. The geological information contained in this report has been abstracted mainly from published bulletins of the Research Council of Alberta, Province of Alberta.

It is hoped that this publication and others to follow will serve to acquaint all those interested with the characteristics of Canadian coals and as an aid in exploitation of our coal resources, and will result in their more efficient utilization to the benefit of both producer and consumer.

R. E. Gilmore,
Chief, Division of Fuels.

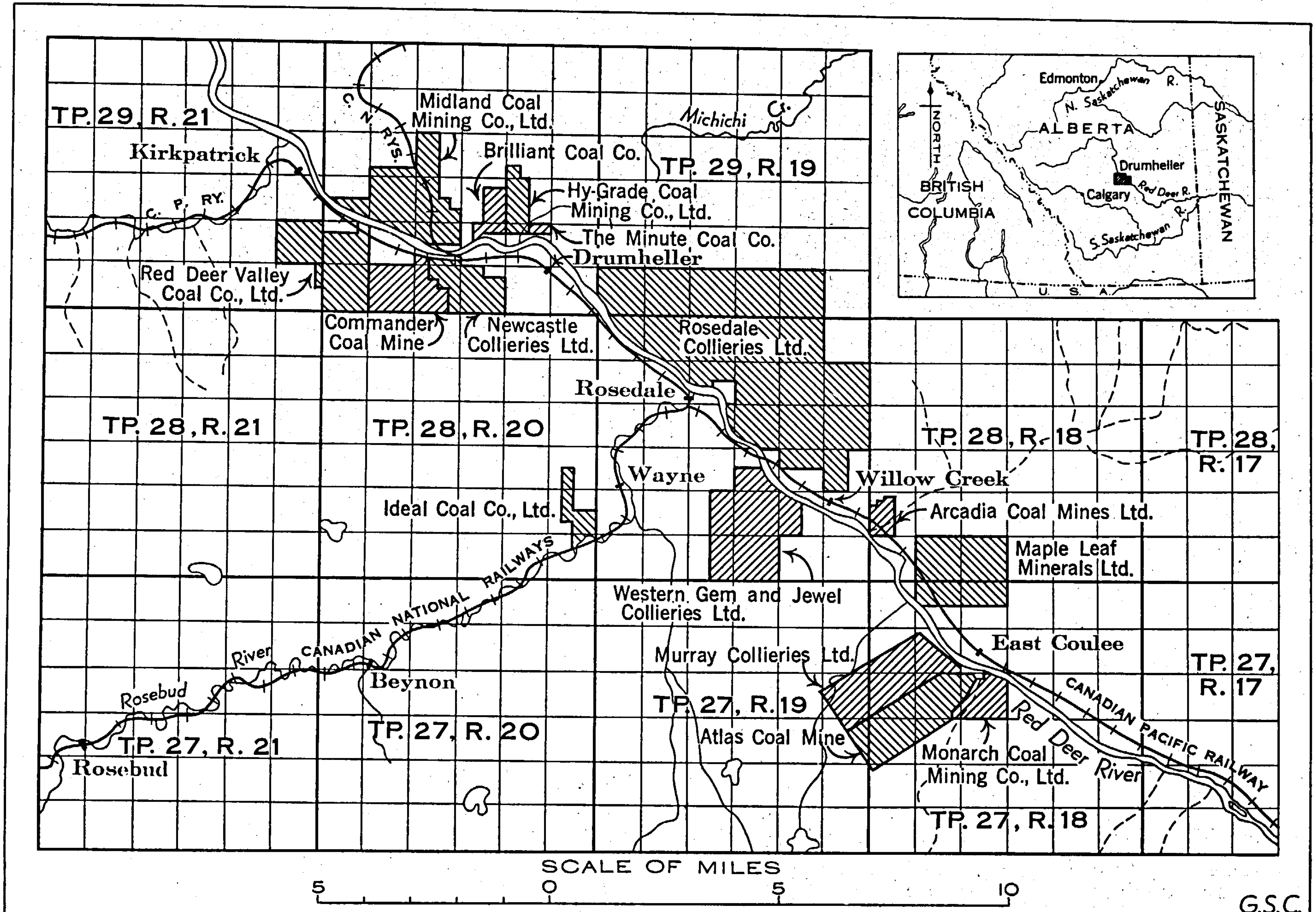

Figure 1 - Map of Drumheller Coal Area.

Chapter I

DESCRIPTION OF COALFIELD AND SEAMS(1)

In the province of Alberta coal occurs in three geological series of horizons, namely (a) the Kootenay, (b) the Belly River, and (c) the Edmonton. The first lies along the eastern face of the Rocky Mountains and parallel thereto; the second and younger lies east of the first and partly up the eastern side of the province; and the third and youngest along the central portion of the province.

In 1924 the horizons were arbitrarily subdivided by J.A. Allan, of the Alberta Research Council(1), into 46 areas or coal districts which were subsequently increased in 1940 in a revised coal map(2) to 49 areas (See Figure I). Each area was named after some mining centre, town or geographical feature within its boundaries, and although the boundaries are more or less arbitrary they were based upon the geological and chemical characteristics of the coals(3). The Coal Sales Act, 1925 (Statutes of Alberta, 1921, Chapter 21) assented to April 10, 1925, legalizes the coal areas insofar as they are used in the sale of coal.

The Drumheller area is one of fifteen which are underlain by the Edmonton coal-bearing formation. This formation, according to Allan, is distributed over the western two-thirds of the Province of Alberta, and occupies a broad trough-shaped structure with a north-west trend, so that the lower members of the formation outcrop on either side of the structure in the foothills on the west, and along the eastern portion of Alberta. The Red Deer River has cut its valley through the entire thickness of the Edmonton formation, and in the Drumheller area the lower 650 feet of beds are exposed in the badlands along the sides of the valley.

(1) "Geology of Drumheller Coal Field, Alberta": John A. Allan, Report No.4 - Scientific and Industrial Research Council of Alberta, 1924.

(2) Coal Areas Map of Alberta, Map No. 18, 1940 - prepared by J.A. Allan.

(3) "Geology of Alberta Coal": John A. Allan - Bulletin of the Canadian Institute of Mining and Metallurgy, No. 156 (April 1925) pp - 387-405).

The Edmonton formation is composed of light to dark coloured shales, bentonitic clays and sandstones, coal seams, and carbonaceous bands. These were deposited during the brackish water period which succeeded the marine invasion of the central part of the continent during Cretaceous times.

A complete typical section of the Edmonton formation as measured along the Red Deer Valley, where it outcrops in the Ardley, Big Valley, Carbon and Drumheller coal areas, is shown below. The measured section contained 1224 feet of strata with an aggregate of 62 feet of coal. The coal seams, from the oldest to youngest, have been numbered from 1 to 14, respectively. They vary in thickness from less than one foot to a maximum of about 20 feet, and in themselves vary laterally throughout the formation.

The Drumheller coal area is situated in the vicinity of the town of Drumheller, some 85 miles east-northeast of Calgary. It includes an area of twelve townships and is cut diagonally from northwest to southeast by the valley of the Red Deer River. As only the lower two-thirds of the Edmonton strata occur in this area, the highest coal seam observed here is the carbon or No. 11 seam, which occurs in the northwest quarter of section 33, township 27, range 21, about 3 miles north of Rosebud River.

All of the coal seams, from the lowest up to seam No.9, are exposed along the sides of the Red Deer valley between East Coulee at the mouth of Kneehills Creek, a distance of about 20 miles. The various seams occurring in this area have been described by Allan as follows:-

<u>Seam No. 0</u>: This seam outcrops close to the level of the Red Deer River below the entrance to the Star mine. Here the seam is about 14 inches thick, but it thins towards the east, and is of no commercial importance.

<u>Seam No. 1</u>: This seam, formerly known as the "Deep or Drumheller" seam, is the lowest workable seam. It is the thickest seam in the area and ranges on the average from 4 to 7 feet in thickness. The true dip of the seam is in a west-southwesterly direction at the rate of about 20 feet to the mile. It is divided into two benches by a band of bentonite varying in thickness from a fraction of an inch up to twenty inches. In some places this band of impurities is too wide to warrant its extraction in order to work the lower bench. In several of the mines there is also a band of hard "granular" coal near the top of the lower bench, as well as below the bentonite parting in the lower bench. This granular coal is fine textured, hard, and a little heavier than the normal coal. The granular texture is due to the presence of innumerable conchordal fracture surfaces, and although not attrac-

tive on the market, analyses show that its heating value is comparable to the normal coal. All of the mines are working the upper bench, which varies from 5 feet to 6 feet 4 inches in thickness, whereas at some of the mines both benches are mined, the low bench varying from 18 to 42 inches in thickness. The coal is bright when freshly mined, but becomes dull when exposed to the air, and disintegrates to some extent on weathering.

Seam No. 2: This coal seam occuring some 35 to 50 feet above No. 1, varies from 22 to 40 inches in thickness with about a half inch band of bone near the centre. The coal seam mined at East Coulee, which was formerly considered to be the No. 1 seam, has been correlated in recent years with the No. 2 seam. It is now often referred to in that district as the East Coulee seam. The coal, when fresh, has a dull lustre.

Seam No. 3: This seam is seldom more than one foot thick and is of no commercial value.

Seam No. 4: This seam is about one foot thick and only useful as a marker.

Seam No. 5: Next to No. 1 seam the No. 5 seam, formerly known as the "Top" or "Newcastle" seam, was the most important commercial producer in the Drumheller area. It varies in thickness from 3 feet 6 inches to 5 feet 5 inches, and the average thickness where mined was about 4 feet 8 inches of relatively clean coal. Generally there is one band of bone varying from a mere parting to a maximum of 12 inches, but on the average is less than 3 inches in thickness. The coal as mined is shiny and irregular in size and shape, and slacks readily but not uniformly. The seam thins to the east and south. Although in 1921 there were eleven mines working the seam, mining has been discontinued near Drumheller, and has been confined to small operations near Willow Creek, and more recently at Rosedale.

Seam No. 6: This seam varies from 6 inches to 37 inches in thickness and is mainly a carbonaceous shale.

Seam No. 7: This seam, formerly known as the "Vulcan" and "Daly" seam, varies in thickness from less than one foot to a maximum of 6 feet 8 inches, but in this case would include about a 24 inch shale parting. Laterally, this seam changes in thickness and quality very rapidly, and at present is only being worked at one mine near the mouth of Michichi Creek in a very small operation.

Seam No. 8: This coal seam varies in thickness from a fraction of an inch to a maximum of 4 feet of clean coal, but is unimportant commercially.

Seam No. 9: Unimportant - with less than one foot of coal.

Seam No.10: This seam is of no commercial value as it does not include more than a few inches of clean coal.

Seam No.11: This seam, sometimes referred to as the "Carbon" seam because it has been mined near Carbon, west of the Drumheller area, is the uppermost seam that has been recognized in the Drumheller area. Limited mining in this seam has been conducted about 3 miles north of the Rosebud River where the coal seam was about 3 feet 7 inches thick.

Coal mining in this area has been conducted in the five seams numbered 1, 2, 5, 7 and 11, but the most productive operations in recent years have been in seams No. 1 and No. 2.

Section of Edmonton Formation in Red Deer Valley (4)

Feet	Description
	(Contact overlain disconformably by Paskapoo)
60	Sandstone and shale
20	No. 14 seam (Ardley)
50	Rock
3	No. 13 seam
170	Rock
1	Volcanic tuff
50	Rock
5	No. 12 seam (Thompson)
90	Rock
6	No. 11 Seam (Carbon (Paton)
155	Rock
3	Corbicula zone
20	Rock
3	Ostrea zone
85	Rock
	Ornithominus zone, 110 ft.above No.9
2	No. 10 seam (Marker seam)
60	Rock
1	No. 9 seam
15	Rock
2	No. 8 seam
100	Rock
4	No. 7 seam (Daly)
25	Rock
2	No. 6 seam
70	Rock
5	No. 5 seam (Newcastle)
15	Rock
1	No. 4 seam
10	Rock
1	No. 3 seam
10	Rock
3	No. 2 seam
30	Rock
6	No. 1 seam (Drumheller)
40	Rock
1	No. 0 seam
100	Rock
	(Bearpaw shales at base)
1224	Total thickness of the Edmonton formation

(4) Geology: Part V - Coal Areas of Alberta:- J.A. Allan, Research Council of Alberta, Report No. 34, 1943 (Table 5)

Chapter II

DESCRIPTION OF THE MINES

Coal mining in the Drumheller area centres around four towns along the Red Deer River, namely, Drumheller, Rosedale, Willow Creek, and East Coulee, from northwest to southeast, respectively, and at Wayne on the Rosebud River (see Figure 2). For convenience of investigation the area may be divided into three main districts as follows:-

1. Drumheller:- Township 29, range 20 and 21, west of the 4th meridian, in the vicinity of the town of Drumheller.

2. Rosedale:- Township 28, range 18 to 20, west of the 4th, in the vicinity of the towns of Rosedale and Willow Creek; and townshin 27 and 28, range 19 and 20, west of the 4th meridian, in the vicinity of the town of Wayne.

3. East Coulee:- Township 27, range 18, west of the 4th meridian, in the vicinity of the town of East Coulee.

The physical and chemical survey of the coals from the Drumheller area was over a period of years beginning in 1944, and was confined to several typical larger operations in each of the above districts with a view to obtaining a cross-sectional picture of each of the seams being mined. Thus, although in 1946 there was a total of some 24 collieries in operation, the survey deals only with thirteen of them, as listed below. However, these collieries accounted for almost 75% of the production of the whole area.

List of Mines Investigated(5)

Operator	Mine	Seam No.	Sec.	Tsp.	Rg.	W4.
Drumheller District						
1. Newcastle Collieries Ltd.	Newcastle	1	3	29	20	W4
2. Red Deer Valley Coal Co.Ltd.	Red Deer Valley	1	7	29	20	W4
3. Midland Coal Mining Co.Ltd.	Midland	1	9	29	20	W4
4. Regal Coal Co.Ltd.	Commander	1	9	29	20	W4
5. Hy-Grade Coal Mining Co.Ltd.	Hy-Grade	1	11	29	20	W4
6. Brilliant Coal Co.	Brilliant	1	10	29	20	W4
7. The Minute Coal Co.	Minute	7	14	29	20	W4
Rosedale District						
8. Rosedale Collieries Ltd.	Star	1	28	28	19	W4
9. Rosedale Collieries Ltd.	Rosedale	5	28	28	19	W4
10. Arcadia Coal Mines Ltd.	Arcadia	2	7	28	18	W4
East Coulee District						
11. Murray Collieries Ltd.	Murray	2	29	27	18	W4
12. Monarch Coal Mining Co.Ltd	Western Crown	2	20	27	18	W4
13. Regal Coal Co.Ltd.	Atlas	2	21	27	18	W4

(5) "Coal Mines in Canada" - Publication No.4-1, January 23,1946, Division of Economics, Mines & Geology Branch, Dept. of Mines & Resources.

DRUMHELLER DISTRICT

Newcastle Collieries Ltd.

This company, with an output of over 11,000 tons of coal during 1944, and previously known as the Alberta Block Coal Co. Ltd., operates the Newcastle mine (Alberta mine No.620) at a point about one mile southwest of the town of Drumheller, in the No.1 seam. During the period when the samples were collected in 1945 the mine was entered by a shaft 100 feet deep, the main level having been driven both southwest and southeast, the latter for a distance of about 6200 feet.

The thickness of the seam worked at this mine averaged about 5 feet 6 inches. A typical section of the seam consisted of the following: 1 to 2 feet of top coal and bone; 1 to 3 inches of bone or clay; 4 to 5 feet of coal, with a bone intrusion in places varying up to 8 to 10 inches; and 4 to 6 inches of clay and bone. Throughout a large part of the seam there is a bottom bench of 3 to 4 feet of rather dirty coal which is not mined. The advance room and pillar method of mining was employed, with rooms approximately 25 feet wide being driven at 45-foot centres, leaving 12 to 15 foot pillars which were not extracted. The coal was machine-mined by undercutting in the 4 to 6 inch bentonite bed, and then shearing.

The coal was hand-loaded into 1700 to 1800 lb. capacity cars and hauled by horse to the levels, where a main and tail haulage system brought the cars in trips of 45 to the bottom of the shaft to be elevated by means of a steam-operated, balanced-cage hoist to the surface.

Bankhead

At the tipple the coal was discharged by the end dump cage onto a 1½ in. bar screen (popularly known in the area as the 'mine screen'), 15 feet in length. The oversize was weighed in a weigh-pan and then dumped onto a steel conveyor-type picking table. The hand-picked +1½ in. lump was then fed to a single decked shaker screen fitted at the head end with 1 in. rd., followed by a 2 or 2½ in. rd. hole screen, and at the discharge end with a 4 or 5 in. rd. hole screen, resulting in the preparation of the following sizes:-

(a) Plus 4 or 5 in. lump
(b) 2 or 2½ - 4 or 4½ in. stove or egg
(c) 0 - 2 or 2½ in. slack (Degradation from lumps)

The 0 - 1½ in. slack from the "mine screen" was collected in a bin, and in admixture with the 0 - 2 or 2½ in. slack from the above screening, was elevated to a rotary screen equipped from feed to discharge end with the following screens: (a) 5/8 in. or 3/4 in. sq. mesh (2/3 of length of screen), and (b) 1-3/8 in. sq. mesh (remaining 1/3 of screen). This screening resulted in the following sizes:-

(a) 1-3/8 in.sq. to 2 or 2½ in.sq. Range Nut (hand picked on short belt conveyor)
(b) 5/8 or 3/4 to 1-3/8 in.sq. Nut Pea (Stoker)
(c) 0 to 5/8 or 3/4 in.sq. Slack

In addition to the above sizes, the plus 1½ in. lump coming over the 1½ in. "mine screen" was sometimes loaded direct as "singled screened lump". Thus the various commercial sizes produced at this mine, and trade named Newcastle and A.B.C., were as follows:

1. Double screened lump	Plus 4 or 5 in. rd.
2. Single screened lump	Plus 1½ in. bar.
3. Stove or egg	2 or 2½ to 4 or 5 in.rd.
4. Range nut	1-3/8 in.sq. to 2 or 2½ in.rd.
5. Nut pea (Stoker)	5/8 or 3/4 in.sq. to 1-3/8 in.sq.
6. Slack	0 to 5/8, 3/4 in.sq. or 1½ in.bar.

Red Deer Valley Coal Co. Ltd.

This company, which produced over 188,000 tons of coal during 1944, operates the Red Deer Valley mine (Alberta mine No. 402) near Nacmine, Alta., just west of the town of Drumheller.

The coal was mined in the No. 1 seam, which lies about 800 feet below the surface in this area, the mine being entered by a shaft. The seam varies from 5 to 6 feet in thickness, and was mined by the room and pillar system using undercutting and shearing machines. The coal was brought to the surface by means of a balanced-cage hoist in 3200 lb. capacity cars.

Bankhead

During 1944 when the samples for this survey were collected, the coal was dumped by means of an end dump tippling arrangement onto a 1½ bar screen (mine screen). The oversize was weighed in a weigh pan and then discharged onto a double-decked, double acting marcus shaker screen, fitted on the upper deck with a 15-foot section of eliptic-holed screens, 3-3/4 x 4½ in., and on the lower deck with 2 in. rd. hole screens. This initial screening resulted in the following products:

(a) Plus 4 or 5 in. (approximate rd. hole) lump
(b) 2 in.rd. - 4 or 5 in. egg or stove
(c) 0 - 2 in. slack (degradation from lump)

Normally the 2 - 4 or 5 in. size and 0 - 2 in. degradation slack in admixture with the 0 - $1\frac{1}{2}$ in. slack from the 'mine screen' were conveyed by belt to an elevator and then elevated to a triple-decked plato·vibrating screen, the upper deck being fitted with a 2 in. sq. mesh screen, the middle deck with a $1\frac{1}{4}$ in.sq. mesh screen, and the low deck with a 1/2 in.sq. mesh screen. As a result of this screening the following sizes were produced:

(a) 2 in.sq. - 4 or 5 in. (approximately) - egg
(b) $1\frac{1}{4}$ - 2 in.sq. - nut
(c) 1/2 - $1\frac{1}{4}$ in.sq. - stoker
(d) 0 - 1/2 in.sq. - slack

The lump coal may be rescreened at the end of the marcus screen on a 10 in. screen to produce the following:

(a) Plus 10 in. - large or 'super' lump
(b) 4 or 5 - 10 in. - shovel lump.

All the lump coal was handpicked on a steel apron conveyor, whereas the minus 4 in. coal was handpicked on a belt conveyor.

The lump coal was loaded direct to cars by an Ottumwa box car loader, whereas the smaller sizes were fed by spiral chutes to bins and loaded separately by means of a reciprocating loader, after being rescreened, using a 2 in.rd. screen for the egg, and a $1\frac{1}{4}$ in.rd. screen for the nut, and a 1/2 in.sq. for the stoker size. Only one of these smaller sizes could be loaded at a time.

Thus the various commercial sizes, trade named "Glocoal" and "10-5", which could be produced at the mine were as follows:

1. Super lump	Plus 10 in.
2. Shovel lump	4 or 5 - 10 in.
3. Double screened lump	Plus 4 or 5 in.
4. Egg or stove	2 in.rd. - 4 or 5 in.
5. Nut	$1\frac{1}{4}$ in.rd. - 2 in.rd.
6. Stoker	1/2 in.sq. - $1\frac{1}{4}$ in.rd.
7. Slack	0 - 1/2 in.sq. or 0 - $1\frac{1}{4}$ in.bar

Midland Coal Mining Company, Ltd.

This company, operating the Midland mine No. 2 (Alberta mine No. 367), near Midlandvale, Alta., about 4 miles west of Drumheller, produced almost 224,000 tons of coal during 1944.

This mine, opened in 1929, was entered by a shaft 125 feet deep to the top of the coal seam. The main haulage level was about 4500 feet long in a northwest direction at the time the coal sample for the survey was collected in 1944.

The No. 1 seam worked at this mine varied from about 4 ft. 6 in. to 7 ft. in thickness, with an average of about 5 ft. 6 in. In general the seam from top to bottom consisted of 6 in. coal; 2 in. clay; 4 ft. 9 in. coal (with a bone parting varying from 4 to 10 in.); 8 in. granular coal (irregular); 4 in. coal (sometimes clay); and 5 ft. bony coal. The bottom five feet of dirty coal, which comprises the lower bench of the seam, was not being mined.

Mining is conducted by the room and pillar method with rooms about 27 ft. wide at 45 foot centres, the pillars being withdrawn on retreating. The coal was extracted by undercutting in the clay band above the bottom bench, and by vertical shearing.

All the coal was hand loaded into 2400 lb. capacity cars, horse haulage and battery locomotives being employed from the face, and for subsidiary haulage, while main and tail haulage as well as the endless rope type was employed in the main levels. The coal was brought to the surface by means of an electric hoist with self-tripping balance cages.

Bankhead

In the tipple the cars of coal were dumped onto a $1\frac{1}{2}$ in. bar screen ("mine screen"), from which the oversize was passed to a weigh pan. The $1\frac{1}{2}$ in. lumps and the $1\frac{1}{2}$ in. slack then passed together onto a reciprocating single-decked marcus screen fitted usually with a 4 in. rd. hole screen, but when required, with larger screens up to 6 in. The plus 4 in. lump passed passed over a reciprocating steel picking table where the impurities were picked out by hand and placed on a central elevated trough attached to the main table, and discharged onto a scraper conveyor to a bin for disposal. When required the plus 4 in. lump could be screened at the tail end of the marcus on a 10 in. screen to produce plus 10 in. large lump and 4 to 10 in. lump.

The 0 - 4 in. coal dropped onto a conveyor belt and was delivered to the first of two rotary screens fitted at the head end with a 1 or 1-5/16 in.sq. mesh screen, and at the discharge end with a 1-7/8 in. sq. mesh screen resulting in the production of the following sizes:-

(a) 1-7/8 - 4 in. Egg (hand-picked on a conveyor belt)
(b) 1 or 1-5/16 - 1-7/8 in. Nut
(c) 0 - 1 or 1-5/16 Slack (stoker slack)

The slack was conveyed by belt to a second rotary screen fitted with a 1/2 in. sq. mesh screen at the head end, and a 5/8 in. sq. mesh screen at the tail end, resulting in:-

(a) 5/8 - 1 or 1-5/16 in. Stoker
(b) 0 - 5/8 in. Slack

The lump coal was loaded direct to box cars by an Ottumwa loader, whereas the smaller sizes were stored in bins prior to loading with portable loaders.

Thus the various commercial sizes, marketed under the trade name "Midland", which were or could be produced, were as follows:

1. Large lump	Plus 10 in.
2. Lump	4 - 10 in.
3. Double screened lump	Plus 4 in. rd.
4. Egg or stove	1-7/8 in.sq. - 4 in.rd.
5. Nut	1 or 1-5/16 - 1-7/8 in.sq.
6. Stoker (Pea)	5/8 - 1 or 1-5/16 in.sq.
7. Slack	0 - 5/8 in., or 1, or 1-5/16 in.sq., or 0 - 1-1/2 in.bar

The indications were that depending upon market demands and production factors changes in the various screens were made from time to time and thus, although coal was sold according to a definite trade size designation, the screen limits were not necessarily constant.

Some so-called "granular lump" was also reclaimed for local sales. This coal was not the typical "granular" coal known in the area, but was more or less a bony coal.

Regal Coal Co. Ltd. - Commander Mine

The Commander Coal Mine (Alberta Mine No. 422), owned and operated by the Regal Coal Co., Ltd., situated west of Drumheller near the Midland mine, was a new mine. In 1944, when samples were collected for this survey, it was still in the development stage. The mine was entered by a shaft from which the main haulage way was struck off for about 5300 feet.

The No. 1 seam mined at this colliery was very similar to that occuring in the Midland mine, and had an average thickness of about 5 ft. 6 inches, with lateral variation from about 4 feet 6 inches to 7 feet. The seam occurred in two benches, with about 5 feet of mineable coal in the top bench, and about the same thickness of inferior coal in the lower bench.

Mining was effected by the room and pillar system, the coal being undercut in the band of bentonite or bony coal separating the two benches of the coal seam. The coal was hand-loaded into $4\frac{1}{2}$ or 5 ton capacity cars and delivered by trolley locomotive to the bottom of the shaft. Here a balanced-cage hoist brought the cars of coal to the surface.

Bankhead

At the time the mines was visited the tipple was not completed. The coal was end dumped onto a $1\frac{1}{2}$ inch bar screen, the oversize being weighed in a weigh pan prior to being screened on a series of shaker screens. The ultimate aim was to arrange the equipment so as to produce various commercial sizes normally produced in the Drumheller field, such as lump, stove or egg, nut, stoker, and slack. It was indicated that the mine would be developed for an output of about 1500 tons per day. During 1944 the mine produced somewhat more than 69,000 tons of coal.

Hy-Grade Coal Mining Co. Ltd.

This company, formerly operating on No. 5 seam, opened a new mine (Alberta Mine No. 1421) in 1933 on No. seam. This mine, for a short time operating under the name of Fireside Coal Co. Ltd., is situated about one mile west of Drumheller on the north side of Red Deer River, directly opposite the Newcastle mine, which is on the other side of the river.

The mine was entered by an 8 x 16 foot shaft, 100 feet deep to the coal seam. A main level in the coal was driven about 4000 feet north. The workings in 1944 were all to the east of the main level. The east level was struck off the main level some 1800 feet from the shaft and extended northeast about 5400 feet, the workings being carried on to the north and south.

The coal seam was about 4 feet 6 inches thick, and an average section from roof to floor was as follows: coal 6 inches; bentonite clay 1 inch; coal 3 feet; parting 1 inch; "granular" coal 14 inches; bentonite 6 inches; "granular" coal 10 inches (not uniform); bone 6 inches; coal 2 feet. The 6 inch bentonite band splits the seam into two benches. In most places only the top bench was being mined, but north of 5 East both benches were being mined, the low coal being of somewhat better quality.

The coal is mined by the room and pillar system, the rooms being about 27 feet wide and the pillars, which are not extracted from 12 to 15 feet in width. The coal is worked on the advance, the cut being made in the 6 inch bentonite band separating the upper and lower coal benches. After being shot down the coal is hand-loaded into one ton capacity wooden cars and hauled to the main level by horse. The cars, in trips of about 35, are then brought to the bottom of the shaft by a main and tail haulage system, and subsequently to the surface by an electrically operated single drum hoist, using balanced cages.

Bankhead

In the preparation house the coal was dumped onto a $1\frac{1}{2}$ inch bar screen (miner's screen), the oversize passing to a weigh pan. After being weighed the plus $1\frac{1}{2}$ in. lumps were discharged onto a reciprocating quadruple decked balanced shaker screen, of the Marcus type, in which the upper decks had a forward moving action, and the lower decks a backward moving action. The top deck was fitted in the upper section with $1\frac{1}{2}$ in. slot screens, 4 in. rd. hole, and 3 in. rd. hole screens, in succession from the head end, and with $1\frac{1}{2}$ in. slotted screens in the bottom deck. Thus on the upper decks there was produced plus 3 or 4 in. lump, and $1\frac{1}{2}$ to 3 or 4 in. egg size. The lump was handpicked and loaded direct to cars by means of a retarding type steel conveyor. The egg size was also handpicked, after being by-passed to a side picking table.

The 0 - $1\frac{1}{2}$ in. coal from the above passed to the top deck of the lower section of the screen fitted with a 3/4 in. slotted screen producing 3/4 to $1\frac{1}{2}$ in. nut, which was by-passed onto a side steel picking table and then loaded direct to cars.

The 0 - $1\frac{1}{2}$ in. slack from the "miner's screen" was mixed with the 0 - 3/4 in. degradation product, from the lump screening, in a bin. When stoker coal is prepared this slack mixture was elevated by bucket to a rotary screen fitted with a 3/4 in. mesh square screen making 3/4 - $1\frac{1}{2}$ in. nut-pea or stoker, and 0 - 3/4 in. slack. The nut size was somewhat larger than the stoker size as it was screened entirely on slotted screens. All the small sizes were loaded by means of a special chute.

Thus the various commercial sizes prepared for marketing under the trade name "Hy-Grade" during 1944 were as follows:

1. Double screened lump	Plus 3 or 4 in. rd. hole
2. Single screened lump	Plus $1\frac{1}{2}$ in. bar
3. Egg or stone	$1\frac{1}{2}$ in. slot - 3 or 4 in. rd.
4. Nut	3/4 - $1\frac{1}{2}$ in. slot
5. Stoker (nut pea)	3/4 in.sq. - $1\frac{1}{2}$ in. bar
6. Slack	0 - 3/4 in. sq., $1\frac{1}{2}$ in. bar, or larger

The single screened lump is sometimes referred to as Mine Run because it consists of all the lumps passing over the "mine screen" ($1\frac{1}{2}$ in. bar screen).

The average output of this mine varied from 300 to 400 tons per day and during 1944 produced almost 93,000 tons of coal.

Brilliant Coal Company

The above company is the successor to the Drumheller Consolidated Collieries, which started operations in 1928 in the No. 5 seam. In 1932, after the company reorganization, operations were terminated in No. 5 seam because the coal was of inferior quality. The shaft was deepened and since that time coal from No. 1 seam has been produced. In 1944 the mine produced over 93,000 tons of coal.

The mine (Alberta Mine No. 1258) is situated near Midlandvale, about 1½ miles west of Drumheller on the south side of Red Deer River, and is entered by a shaft 125 feet deep to the bottom of the seam.

The No. 1 seam here, as in other locations, occurs in two benches, with only the top bench containing suitable coal. This top bench, which averages about 6 feet in thickness, has a typical section from top to bottom as follows:- 2 in. clay; about 3 ft. 6 in. coal; 2 to 4 in. shale and bone; 12 to 15 in. "granular" coal; and 6 in. bentonite. The "granular" coal is irregular and intrusions of ironstone appear from place to place.

Mining was carried on by the room and pillar system, the rooms being about 25 ft. wide, with the pillars varying from 12 to 15 feet in width. The cut was made in the 6 in. bentonite band and the coal was sheared vertically. The coal was hand loaded into about 2800 lb. capacity cars, hauled to the main entries by horse, and drawn in trips of about 45 cars by battery locomotive to the bottom of the hoist, a distance of about 1½ miles. The workings were to the north and south of the main haulage way.

Bankhead

The coal was brought to the tipple by a balanced cage hoist, and each car was end dumped onto a 1½ in. bar screen ("miner's screen"). The oversize, after being weighed in a weigh pan, was discharged to a shaker screen fitted from head to tail end with the following screens: 1 in. rd. hole, 2 in. rd hole, and 4 in. rd. hole. The plus 4 in. lump, which was hand picked, was loaded direct to cars with the aid of a portable drag conveyor loader. The minus 4 in. coal together with the 1½ in. slack from the miner's screen passed by chute to a belt conveyor, taking the coal to a subsidiary screening house. Here the coal was passed over a short stationary 5/8 in. bar screen, where fine slack was removed in order to take some load off the screens. The coal passing over the 5/8 in. bar screen was separated into various sizes by means of a rotary screen fitted from head to discharge end with the following square mesh screens: 1 in. and 1-13/16 in.

The following sizes were thus prepared:-

(a)	1-13/16 - 4 in.	Egg
(b)	1 - 1-13/16 in.	Nut
(c)	0 - 1 in.	Slack

The above sizes were stored in bins prior to being loaded into cars.

The various commercial sizes produced at this mine, and marketed under the trade name "Brilliant" were as follows:-

1. Double screened lump	Plus 4 in. rd.
2. Single screened lump	Plus $1\frac{1}{2}$ in. bar
3. Stove or egg	1-13/16 in. sq. - 4 in. rd.
4. Nut	1 - 1-13/16 in. sq.
5. Slack	0 - 1 in. sq. or $1\frac{1}{2}$ in. bar

Although the output of the mine was about 400 tons per day, its capacity was said to be 500 - 1,000 tons per day.

The Minute Coal Co.

This small mine (Alberta mine No. 1520), with an output in 1944 of just over 8,000 tons, is situated about $1\frac{1}{2}$ miles north of Drumheller and is operating on No. 7 seam. At the time the survey samples were collected in 1944, the mine was entered by a drift into the seam, the entry being driven in about 250 feet. This was a new opening, the earlier working at a nearby location, and in about 3,000 feet, having been abandoned.

The No. 7 coal seam at this mine was about 5 ft. 8 in. thick with a band of bone about 12 to 16 in. in thickness occuring about 22 inches from the floor. Due to the nature of the seam it was apparently difficult to mine this coal cleanly.

The seam was worked by the room and pillar system with the cut being made at the bottom. The coal was hand loaded into small wooden cars and hauled by horse out of the mine to the head of a chute leading to the tipple.

The cars were end dumped onto a long wooden chute and the coal was released by a gate at the bottom of the open chute onto a single decked shaker screen fitted from head to tail end with the following rd. hole screens: 3/4 in., 2 in., and 4 in. In this manner the following commercial sizes, marketed under the name "Good Quality" were produced:-

1. Lump	Plus 4 in. rd.
2. Egg or stove	2 - 4 in. rd.
3. Nut	3/4 - 2 in. rd.
4. Slack	0 - 3/4 in. rd.

The lump was handpicked and stored in a long inclined chute, whereas the smaller unpicked sizes were stored in bin-type chutes, prior to delivery by truck to the railway for loading into cars.

The output was about 30 tons per day, but was subsequently increased to about 60 tons per day.

ROSEDALE DISTRICT

Rosedale Collieries Ltd. - Star Mine (No. 1 Seam)

This company operating the Star Mine (Alberta mine No. 436) on the north side of the Red Deer River near Rosedale, Alta, produced almost 123,000 tons of coal during 1944.

This mine, opened in 1914, is entered by a drift in the coal, which in 1944 was to a distance of about 10,000 feet. This single-tracked main haulage way proceeded in a northwest direction, side entries being driven off to the east and west every 1,600 to 2,000 feet.

The No. 1 seam worked at this mine consisted, on the average, in sections from floor to roof of the following:- 5 in. bone; 1 ft. 6 in. coal; 2 in. bone; 2 ft. 6 in. coal; 1 ft. 2 in. "granular" coal; 8 in. bentonite; 3 ft. 6 in. coal. The 6 in. bentonite separates the seam into two benches. There is quite a lateral variation in the seam, the upper bench varying from 4 ft. to 8 ft. in thickness, whereas the low bench may in some cases be absent, and in others vary from a very thin streak to 3½ ft. In the upper bench the above noted 2 in. bone parting may increase to over 12 in. in thickness. In 1944 when samples were collected for this survey only the top bench was being mined, including the "granular" coal.

Mining was conducted by the room and pillar system, with 25 ft. rooms at 35 ft. centres, the 10 ft. pillars not being extracted. The coal was undercut in either the 6 in. bentonite band or in the "granular" coal, using Sullivan & Goodman machines. A duckbill loader was used in conjunction with the cutters in driving entries, the coal being loaded into 1800 lb. capacity cars. Horses and battery locomotives were used for subsidiary haulage whereas the main and tail system was used in the main haulage way.

Bankhead

The cars of coal were brought from the main entry up a slope by creeper to the top of the tipple where they were dumped by means of a single rotary tippler onto a reciprocating feeder, which delivered the coal to a 1¼ in. bar screen ("miner's screen").

The oversize, after being weighed in a weigh pan, passed over a double decked, balanced shaker screen 18 ft. long and 5 ft. wide. The top deck was fitted from head to tail end with 3 in. rd. and 4 in. rd. hole screens in succession, followed by a dead-plate section used for hand picking the plus 4 in. lump. The minus 3 in. coal fell onto the bottom deck, which was equipped with 2 in. rd. hole screens, making a 2 - 3 in. size. This coal, by means of a deflecting plate placed midway, on the lower deck, was delivered to a 20 in. wide steel picking plate attached to the upper deck of the shaker, and thus moving the coal in the opposite direction. The coal passing the 4 in. screen of the upper deck of the shaker, and thus retained on a 3in. screen, dropped onto the second section of the bottom deck fitted with a screen having slots 1 in. wide and 6 in. long. This screened 3 - 4 in. size met the 2 - 3 in. coal on the picking plate, and was loaded to cars as 2 - 4 in. egg. When "granular" coal occured in the lump coal it was removed by hand and placed on the blind plate of the bottom deck for delivery to cars.

The 0 - 1¼ in. slack passing the "miner's screen" was rescreened on a 1½ in. bar screen to remove some of the flat oversize pieces, which were delivered to the lower deck of the shaker to be included with the egg size. The undersize, mixed with the 0 - 2 in. degradation from the lump screening, was then loaded direct to cars for shipment, and sold as 0 - 2 in. slack.

Thus the various commercial sizes marketed under the trade name "Rosedale" were as follows:-

1.	Lump	Plys 4 in.
2.	Egg or stove	2 - 4 in. rd.
3.	Slack	0 - 2 in.

Rosedale Collieries Ltd. - Rosedale Mine (No. 5 Seam)

In April 1945 this company made a new drift opening in No. 5 seam, about 1700 feet from the Star Mine tipple. At the time this new development was sampled, in November 1946, the main entry had been driven in to a distance of about 1500 feet, and there was one side entry about 1000 feet long.

The seam varied between 42 inches to 54 inches in thickness, and contained a discontinuous parting of bone and/or clay varying to some degree in thickness, but averaging about 3 in.

This new development was mined by undercutting, a Duckbill being employed for loading. At the end of 1946 the maximum output was about 50 tons per day, and it was delivered to the Star Mine tipple and admixed in preparation with this latter mine's output.

Arcadia Coal Mines Ltd.

This mine, the Arcadia No. 2 (Alberta mine No. 1589), owned and operated by the Bullock Coal Sales Ltd., of Calgary, Alta, was opened in August 1943, and during 1944 only produced slightly over 8,000 tons of coal. The mine is situated about two miles northwest of East Coulee in the Willow Creek coulee and operates on No. 2 seam. The No. 1 mine was situated about one-half mile down the creek, and ceased operation in 1942.

The No. 2 mine is entered by means of a drift on the seam, the main level having been driven a distance of about 700 feet at the time the mine was sampled in August 1944.

The No. 2 seam in the development area averaged about 4 ft. 10 in., and in section showed the following from roof to floor:- 10 in. bone, 3 ft. 6 in. coal.

One longwall was in operation in 1944, this being about 160 ft. in length. The coal was undercut and loaded onto a Mavor and Coulson shaker pan conveyor for loading the pit cars. The 10 in. of bone over the coal was used as a roof.

Bankhead

The coal was brought to the surface and end-dumped into a chute, from which it was loaded into trucks for delivery to the tipple at the No. 1 mine. Here the trucks were side dumped, the coal being delivered by means of a stoker feeder to an inclined double-decked shaker screen. The top deck of the screen was fitted at the tail end with 3 x 11 in. slot screens and 3½ in. rd. hole screens resulting in the production of so-called plus 4 in. lump, which was loaded direct to cars. At the head end of the top deck there was a 2 in. rd. hole screen. The coal passing the 4 in. screen and retained on the 2 in. screen was delivered without any further treatment to cars for loading as egg or stove size. The material passing this 2 in. screen dropped onto the head end of the bottom deck. fitted with a 3/4 in. slot screen, making 3/4 to 2 in. nut, and 0 - 3/4 in. slack. These smaller sizes were also loaded direct to cars.

The various commercial sizes produced were thus as follows:-

1. Lump	Plus 4 in.
2. Egg or stove	2 in. rd. - 4 in.
3. Nut	3/4 in. - 2 in. rd.
4. Slack	0 - 3/4 in. or 1½ in. bar

During 1944 the output of this mine was just over 8,000 tons.

EAST COULEE DISTRICT

Murray Collieries Ltd.

This company opened the mine (Alberta mine No. 1491) from which the samples for this survey were collected neat East Coulee, south of the Red Deer River in 1936. The mine, operating on the No. 2 seam, was entered by a drift into the seam in a westerly direction. The main haulage way was somewhat over a mile long, and all the workings were to the southwest.

The seam averaged about 5 ft. 5 in. in thickness, and consisted of fairly clean coal with very few thin intrusions of shale. The bottom few inches was, in some locations, of a bony nature. This seam, at this location, underlies the No. 3 seam by about 14 ft. and overlies the No. 1 seam by about 25 feet, the No. 1 being merely a thin marker seam, and the No. 3 consisting of from 2 to 2½ ft. of clean coal. In the strata above No. 3 seam, No. 5 and No. 7 seams occur in very thin beds.

The coal at this mine was extracted by the room and pillar system, with 23 ft. rooms and 17 ft. pillars. The entries to the rooms were about 10 ft. wide, allowing 90 ft. pillars for support. Usually none of the pillars were extracted because of the bad roof and floor conditions. The coal was cut at the bottom either in the bone or coal, and then vertically sheared in the middle. The shot coal was hand loaded into metal-lined wooden cars with a 3500 lb. capacity, and hauled by horse to the main haulage way. From here the coal was hauled either by trolley or battery locomotive to the mine entry, which was situated about 200 ft. above the level of the valley.

Bankhead

At the mine entry the coal was dumped by means of a rotary tippler onto a 1½ in. bar screen. The oversize was weighed in a weigh pan and then remixed with the slack and carried by scraper conveyor to a 36 in. belt conveyor, which brought the coal down a fairly steep incline a distance of 700 feet to the main preparation house in the valley. Here the coal was first separated on a hanging shaker screen into plus 4 in. lump and 0 - 4 in. slack and smalls. The plus 4 in. was loaded direct to cars whereas the 0 - 4 in. coal was conveyed by belt to a second shaker screen fitted from head to tail end with the following screens:- 5/8 in. rd., 1 in. slot, and 2 in. rd. The products prepared as a result of this screening were: 2 - 4 in. rd. egg, 1 in. slot - 2 in. rd. nut, 5/8 in. rd. to 1 in. slot stoker, and 0 - 5/8 in. rd. slack. All these sizes were conveyed to bins from which they were loaded. The egg, nut, and stoker sizes were rescreened on loading over a 1/2 in. screen. The box car loaders were of the scraper conveyor type.

The various commercial sizes produced at this mine, and sold under the name "New Murray" were thus as follows:-

1. Double screened lump	Plus 4 in. rd.
2. Egg or stove	2 - 4 in. rd.
3. Nut	1 in. slot - 2 in. rd.
4. Stoker	5/8 in. rd. - 1 in. slot
5. Slack	0 - 5/8 in. rd.

When required, the lump was at times further separated on a 10 or 12 in. screen to produce a so-called Cobble size (4 to 10 or 12 in.).

During 1945 the output of the mine was about 500 tons per day, but the capacity was said to be about 1000-1200 tons per day.

The Monarch Coal Mining Co Ltd. - Western Crown Mine

This company opened the Western Crown Mine (Alberta mine No. 1573) on No. 2 seam in 1940. The mine, which was in an advance development stage in 1944 when samples were taken for the survey, was entered by a drift, the main entry being about 3,000 feet long.

The seam worked at this mine was in typical section from roof to floor as follows:- 5 ft. 6 in. coal, 10 in. bone, 2 ft. sandrock, 3 ft. bone and coal. As the seam was being developed the sandrock decreased and in some locations petered out, while the bottom bench of bone and coal appeared to improve in quality. It was thus anticipated that finally there would be about 8 ft. to 9 ft. of coal, with "granular" coal appearing discontinuously in the bottom bench.

During the development stages the coal was cut in the bottom bench, but once rooms were developed it was proposed to make the cut in the 10 in. band of bone between the two benches. The coal will be mined by the room and pillar system with 24 ft. rooms and 10 ft. non-extractable pillars.

Bankhead

As this mine was still in the development stage in 1944 the tipple was rather rudimentary. The coal was brought to a surface chute from which it was delivered by truck to the tipple at railway level some 400 ft. away. Here the coal was elevated to a single decked shaker screen fitted with 4 in. rd. hole screens, resulting in the production of plus 4 in. lump and 0 - 4 in. coal. This latter was elevated to another single decked shaker screen fitted with 2 in. rd. hole screens making 2 - 4 in. egg or stove and 0 - 2 in. slack. Eventually the tipple is to be completely equipped so as to produce lump, egg, nut, stoker and slack.

During 1944 this mine produced just under 21,000 tons of coal.

<u>Regal Coal Co. Ltd. - Atlas Mine</u>

The Atlas mine (Alberta mine No. 1484), owned and operated by the Regal Coal Co. Ltd., was situated about one-half mile east of East Coulee. The mine was entered by a drift in the seam. In 1944, when the samples for this study were collected, the main haulage way on the seam was about 6000 feet long.

The No. 2 seam mined at this colliery was approximately 5 ft. 6 in. thick and contained no extensive bone partings. "Granular" coal appears rather patchy and occurs near the top of the seam.

The coal was mined by the room and pillar method with 25 ft. rooms and 10 ft. non-extractable pillars. The cut was made at the bottom of the seam and the coal was loaded either by hand or by means of Duckbill loaders into 2 ton capacity cars. These were hauled to the main level by horse, and then to the surface by electric trolley and battery locomotives.

<u>Bankhead</u>

At the mine entry the coal was dumped by means of a rotary tippler onto a $1\frac{1}{2}$ in. bar screen ("miner's screen"), the oversize being weighed in a weigh pan. The recombined slack and oversize were then carried by a 36 in. belt conveyor a distance of about 500 feet down the hillside to the tipple in the valley where the coal was discharged onto an inclined double-decked shaker screen. The top deck was fitted with a 4 in. rd. hole screen making 4 in. lump, which was delivered to box cars without further preparation. The 0 - 4 in. coal was conducted by a 36 in. belt conveyor to a secondary screening house where the coal passed over a triple-decked inclined shaker screen. This shaker was fitted as follows:- top deck - 2 in. rd. hole screen; middle deck - varying size screens from 3/4 to $1\frac{1}{4}$ in.; bottom deck - 3/8 in. rd. hole screen. The sizes prepared were thus:- 2 - 4 in. egg; 3/4, 1, or $1\frac{1}{4}$ - 2 in. nut; 3/8 - 3/4, 1, or $1\frac{1}{4}$ in. stoker: and slack. All the above sizes were stored in bins prior to loading, the 2 - 4 in. size being fed to its bin by a special chute, and the smaller sizes by Humphrey ladders in order to reduce breakage.

The various commercial sizes produced at this mine and sold under the trade name "Atlas" were thus as follows: -

1. Lump	Plus 4 in. rd.
2. Stove or egg	2 - 4 in. rd.
3. Nut	3/4, 1, or $1\frac{1}{4}$ - 2 in. rd.
4. Stoker	3/8 - 3/4, 1, or $1\frac{1}{4}$ in. rd.
5. Slack	0 - 3/8, 1, $1\frac{1}{4}$, or 2 in. rd.

During 1944 this mine produced over 152,000 tons of coal.

Chapter III

PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE COALS FROM THE DRUMHELLER AREA

All the samples of coal from the Drumheller area used in this investigation were taken at the mines in the presence of mine officials, and under the supervision of E. Swartzman, of the Division of Fuels.

Approximately 2,000 pounds of run-of-mine coal, representative of the day's output, was collected at each colliery at the tipple, and either bagged or boxed for shipment to Division of Fuels laboratory at Ottawa. Acknowledgement is due to the Fuel Department of the Canadian National Railways for their cooperation in connection with the collection and shipment of all the samples.

The run-of-mine samples, unmodified and not prepared in any manner, were delivered to the laboratory in as fresh a state as possible and with the minimum amount of handling. They were tested as soon as possible so that the physical and chemical properties of the coal could be determined before any serious change could take place as a result of weathering and handling.

The data obtained as a result of testing the coals from each colliery are presented in the following series of tables, as listed below:-

Physical Tests:

Table I - Screen analyses, bulk density and apparent specific gravity.
Table II - Size stability.
Table III - Crushing tests.
Table IV - Grindability.

Chemical Analyses:

Table V - Proximate analyses, calorific value and ash fusibility; also Classification by Rank.
Table VI - Ultimate analyses.
Table VII - Chemical analysis of ash.

Coking Tests:

Table VIII- Swelling and caking properties.

Washing Tests:

Table IX	-	Float-and-sink data on $1\frac{1}{2}$ in. slack.
Table X	-	Chemical analyses and fusibility of ash of float-and-sink fractions of $1\frac{1}{2}$ in. slack.
Table XI	-	Float-and-sink data on $1\frac{1}{2}$ - 4 in. lump.
Table XII	-	Float-and-sink data on plus 4 in. lump. (crushed to pass 4 in.)
Table XIII	-	Chemical analyses of raw coal, clean coal, and refuse 0 - $1\frac{1}{2}$ in. slack.
Table XIV	-	Screen and chemical analyses of sizes prepared from $1\frac{1}{2}$ in. slack, and analyses of the clean coal and refuse of these sizes after washing at a selected gravity.

Washability Curves, based on the float-and-sink data are presented for each of the coals listed.

A full discussion of the tests used in this study, and their significance, is presented in the Appendix to this report.

DRUMHELLER DISTRICT
NO. 1 SEAM
NEWCASTLE MINE, NEWCASTLE COLLIERIES LTD.
DRUMHELLER, ALBERTA

TABLE I

SCREEN ANALYSIS, SPECIFIC GRAVITY, AND BULK DENSITY

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu.ft.	Ash %
Plus 8 in.	24.3	24.3	1.36	51.0	10.9
4 - 8 in.	38.4	62.7	1.38	46.6	11.3
2 - 4 in.	15.4	78.1	1.38	44.6	11.5
1½ - 2 in.	4.0	82.1	1.37	43.3	13.5
1 - 1½ in.	6.2	88.3	1.40	44.3	11.6
3/4 - 1 in.	2.6	90.9	1.37	42.4	11.5
1/2 - 3/4 in.	3.0	93.9	1.41	45.3	12.0
1/4 - 1/2 in.	3.2	97.1	1.41	45.1	13.9
1/8 - 1/4 in.	1.5	98.6	1.39	45.0	15.4
#48 - 1/8 in.	1.2	99.8	} 1.42	} 47.1	20.4
0 - #48	0.2	100.0			28.1
Mine Run		100.0		54.0	12.1
Plus 1½ in.		82.1			11.3
0 - 1½ in.		17.9		50.5	13.2
1/2 - 1½ in.		11.8		44.5	11.7
0 - 1/2 in.		6.1		48.8	18.7

	As Received
Average Size of Run-of-Mine .... in.	5.191

*All Screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test 2 - 3 in. Before Test %	After 2 drops %	After 4 drops %
2 - 3 in.	100.0	62.0	48.0
1½ - 2 in.		11.5	13.0
1 - 1½ in.		11.5	15.0
3/4 - 1 in.		5.0	6.0
1/2 - 3/4 in.		3.5	6.0
0 - 1/2 in.		6.5	12.0
Av'ge Size in	2.50	1.98	1.74
Size Stability %		79.2	69.6

NO. 1 SEAM - NEWCASTLE MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed Screen Sizes	Plus 8 inch lump Screen Analysis Before Crushing %	Plus 8 inch lump Screen Analysis After Crushing %	4-8 inch lump Screen Analysis Before Crushing %	4-8 inch lump Screen Analysis After Crushing %
8 - 10 in.	100.0			
7 - 8 in.			29.2	
6 - 7 in.			25.2	
5 - 6 in.			23.2	
4 - 5 in.		1.0	22.4	0.6
3 - 4 in.		10.3		11.8
2 - 3 in.		27.0		22.2
$1\frac{1}{2}$ - 2 in.		14.7		21.4
1 - $1\frac{1}{2}$ in.		12.6		14.3
3/4 - 1 in.		7.5		8.5
1/2 - 3/4 in.		7.0		6.6
1/4 - 1/2 in.		8.0		6.9
1/8 - 1/4 in.		5.4		4.0
0 - 1/8 in.		6.5		3.7
Av'g part. size in.	9.00	1.65	6.11	1.70
Size reduction ...%		18.3		27.8

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove Index*
Mine Run	39.3
0 - $1\frac{1}{2}$ in.	38.0
0 - 1/2 in.	34.5

*See appendix.

NO. 1 SEAM -- NEWCASTLE MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis: Ash %	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Dry Basis: Sulphur %	Dry Basis: Calorific Value Btu/Lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in.	14.7	10.9	36.2	52.9	0.5	---	2180	2300	2430	250	120	130
4 - 8 in.	14.1	11.3	35.8	52.9	0.5	11,700	2200	2320	2440	240	120	120
2 - 4 in.	13.9	11.5	35.5	53.0	0.5	---	2210	2340	2460	250	130	120
1½ - 2 in.	14.1	13.5	35.6	50.9	0.5	---	2210	2320	2470	260	110	150
1 - 1½ in.	13.5	11.6	35.6	52.8	0.5	---	2200	2300	2480	280	100	180
3/4 - 1 in.	13.2	11.5	36.1	52.4	0.5	---	2200	2320	2470	270	120	150
1/2 - 3/4 in.	14.0	12.0	36.4	51.6	0.5	---	2200	2320	2470	270	120	150
1/4 - 1/2 in.	14.3	13.9	33.2	52.9	0.5	---	2200	2290	2460	260	90	170
1/8 - 1/4 in.	13.1	15.4	34.7	49.9	0.5	---	2200	2300	2500	300	100	200
#48 - 1/8 in.	11.1	20.4	31.7	47.9	0.5	---	2210	2320	2500	290	110	180
0 - #48 ...	6.2	28.1	31.1	40.8	0.5	---	2200	2300	2480	280	100	180
Mine Run	14.5	12.1	36.1	51.8	0.6	11,645	2200	2310	2480	280	110	170
Plus 1½ in.	14.3	11.3	35.9	52.8	0.5	11,820	2210	2330	2510	300	120	180
0 - 1½ in.	14.8	13.2	35.0	51.8	0.5	11,270	2210	2320	2490	280	110	170
1/2 - 1½ in.	14.7	11.7	35.9	52.4	0.5	11,590*	2220	2320	2500	280	100	180
0 - 1/2 in.	15.0	18.7	35.5	45.8	0.5	10,455-	2220	2320	2520	300	100	200

* Calculated.

Classification of Coal by Rank

Specific Volatile Index — 118-Black Lignite

A.S.T.M. classification — Subbituminous B to A

NO. 1 SEAM -- NEWCASTLE MINE

TABLE VI. Ultimate Analyses

	(Mine Run)						
	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	55.2	3.7	0.5	1.2	11.6	9.9	17.9
Dry Basis	67.2	4.5	0.6	1.4	14.2	12.1	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	54.8	4.8	23.2	7.0	2.2	0.03	3.9	0.7	1.0	0.4	1.5	99.53

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" slack)

Swelling Index	-140
Section on Coke Classification Chart	XIII
Physical Properties of By-Product Coke ..	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray Caking Index	NON-CAKING

NO. 1 SEAM -- NEWCASTLE MINE

TABLE IX. Float and Sink Data on 1½ in. Slack
-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.33	35.2	5.0	35.2	5.0	100.0	13.2	1.40	94.8
Sinks 1.33 " 1.40	47.8	8.2	83.0	6.8	64.8	17.6	1.45	30.5
" 1.40 " 1.50	7.0	21.3	90.0	8.0	17.0	44.1	1.55	4.8
" 1.50 " 1.60	1.8	32.5	91.8	8.4	10.0	60.1	1.65	2.3
" 1.60	8.2	66.1	100.0	13.2	8.2	66.1	1.75	1.5
Curve No. 4		2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack
(Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	5.7	37.9	56.4	N.A.*	0.6	1950	2050	2120	170	100	70
Sinks 1.33 " 1.40	9.4	38.1	52.5	N.A.*	0.5	2210	2320	2530	320	110	210
" 1.40 " 1.50	23.9	33.2	42.9	N.A.*	0.5	2400	2540	2750+	350+	140	210+
" 1.50 " 1.60	36.4	27.2	36.4	N.A.*	0.4	2220	2560	2740	520	340	180
" 1.60	74.9	14.2	10.9	N.A.*	0.2	2250	2480	2750+	500+	230	270+

*N.A. - Non-agglomerate.

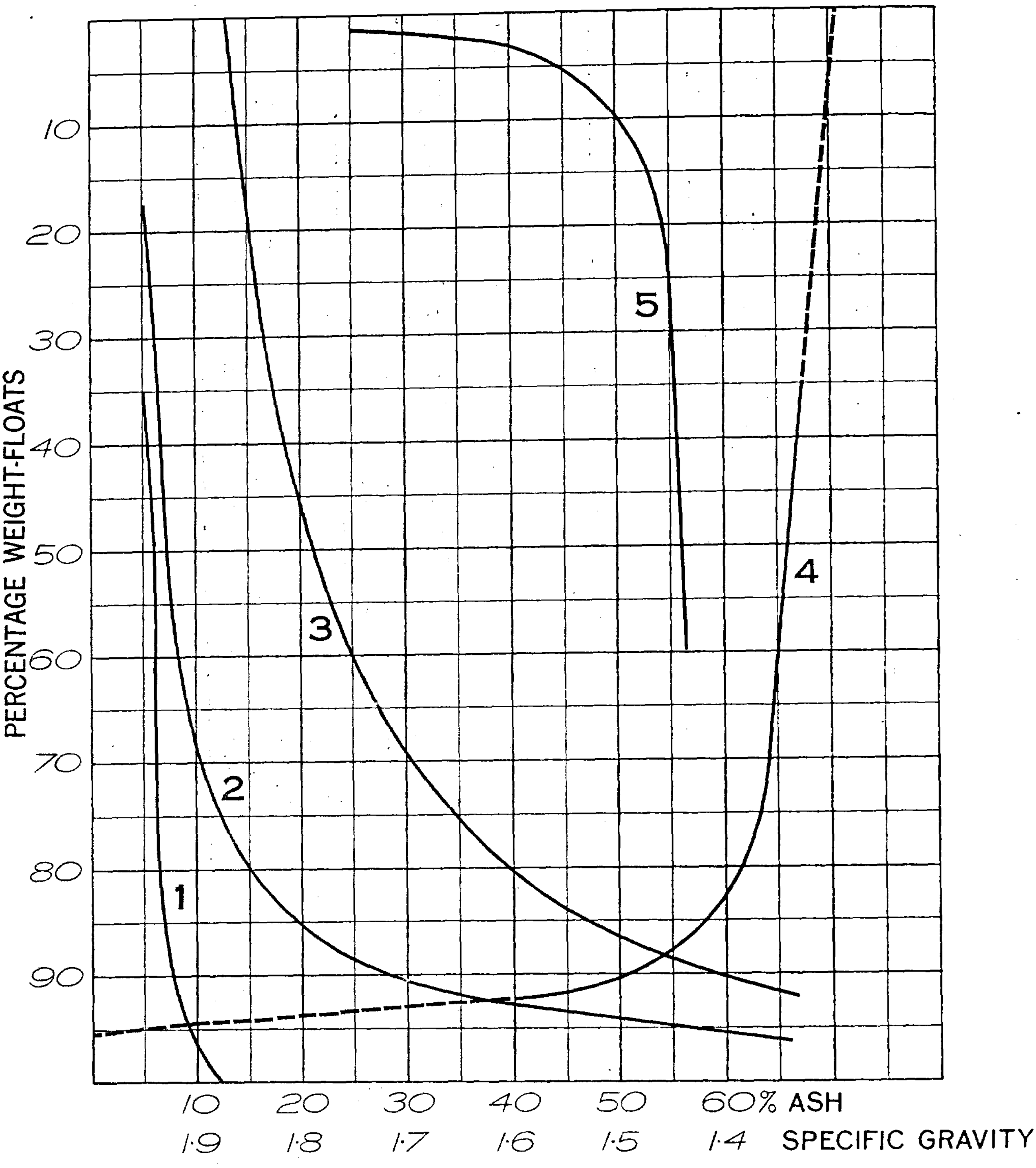

Figure 2 - Washability Curves for 1½ in. slack - No.1 seam, Newcastle Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM -- NEWCASTLE MINE

TABLE XI. Float and Sink Data on $1\frac{1}{2}$-4 in. Lumps

- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash
	%	%	%	%	%	%
Floats 1.33	47.8	5.1	47.8	5.1	100.0	9.8
Sinks 1.33 " 1.40	40.1	10.3	87.9	7.5	52.2	14.1
" 1.40 " 1.50	8.2	21.7	96.1	8.7	12.1	26.8
" 1.50 " 1.60	1.4	30.4	97.5	9.0	3.9	37.5
" 1.60	2.5	41.5	100.0	9.8	2.5	41.5
Curve No.	4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. (Crushed to pass 4 in.)

- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash
	%	%	%	%	%	%
Floats 1.33	25.4	5.4	25.4	5.4	100.0	9.3
Sinks 1.33 " 1.40	67.9	9.4	93.3	8.3	74.6	10.7
" 1.40 " 1.50	6.5	23.1	99.8	9.3	6.7	23.6
" 1.50 " 1.60	0.2	39.7	100.0	9.3	0.2	39.7
Curve No.	4	2	1,2,4	1	3	3

NO. 1 SEAM -- NEWCASTLE MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse
0 - 1½ Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight ....%	100.0	90.0	10.0
Proximate Analysis (dry basis)			
Ash ....%	13.2	9.9	62.1
Volatile Matter ....%	35.0	37.2	19.4
Fixed Carbon ....%	51.8	52.9	18.5
Sulphur ....%	0.5	0.5	0.3
Calorific Value ........B.T.U./lb.	11270	11840	4460
Fusion Point of Ash ....°F.	2320	2230	2590
Melting Range of Ash ....°F.	280	310	310
Coking Properties	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of These Sizes after Washing at a Gravity of 1.50

	Floats			Sinks				Cum.			
Screen Sizes	Weight %	Ash %	F.P.A. °F.	Weight %	Ash %	F.P.A. °F.	Weight %	Weight %	Ash %	Sulphur %	F.P.A. °F.
1/2 - 1½ in.	88.4	9.3	2240	11.6	68.4	2620	65.9	65.9	11.7	0.5	2320
0 - 1/2 in.	84.6	8.3	2020	15.4	71.4	2470	34.1	100.0	18.7	0.5	2320

DRUMHELLER DISTRICT
NO. 1 SEAM
RED DEER VALLEY MINE, RED DEER VALLEY COAL CO., LTD.
NACMINE, ALBERTA

TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu.ft.	Ash %
Plus 8 in..	24.3	24.3	1.34	52.1	7.8
4 - 8 in..	32.2	56.5	1.33	49.3	8.9
2 - 4 in..	21.4	77.9	1.33	45.6	10.3
1½ - 2 in..	4.1	82.0	1.34	43.0	10.0
1 - 1½ in..	6.1	88.1	1.34	43.8	11.4
3/4 - 1 in..	2.9	91.0	1.33	43.0	11.4
1/2 - 3/4 in..	3.2	94.2	1.34	43.5	12.5
1/4 - 1/2 in..	3.1	97.3	1.37	43.0	12.4
1/8 - 1/4 in..	1.4	98.7	1.37	42.4	14.1
#48 - 1/8 in..	1.0	99.7	1.38 (#48 - 1/8 in. and 0 - #48)	49.0 (#48 - 1/8 in. and 0 - #48)	19.8
0 - #48	0.3	100.0			26.8
Mine Run		100.0		55.3	8.6
Plus 1½ in..		82.0			8.2
0 - 1½ in..		18.0		48.3	12.6
1/2 - 1½ in..		12.2		44.4	11.7
0 - 1/2 in..		5.8		45.6	14.9

	As Received
Average size of Run-of-Mine .... in.	5.518

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	66.5	53.5
1½ - 2 in.		13.5	15.5
1 - 1½ in.		10.5	12.5
3/4 - 1 in.		3.0	4.5
1/2 - 3/4 in.		2.5	5.0
0 - 1/2 in.		4.0	9.0
Av'g Size in.	2.50	2.08	1.86
Size Stability		83.2	74.4

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed Screen Sizes	Plus 8 inch Lump Screen Analysis Before Crushing %	 After Crushing %	4-8 inch Lump Screen Analysis Before Crushing %	 After Crushing %
14 - 16 in.	25.1			
12 - 14 in.	10.3			
10 - 12 in.	20.6			
8 - 10 in.	44.0			
7 - 8 in.			28.6	
6 - 7 in.			19.9	
5 - 6 in.			21.7	
4 - 5 in.			29.8	
3 - 4 in.		4.2		6.3
2 - 3 in.		39.6		39.3
$1\frac{1}{2}$ - 2 in.		16.8		18.8
1 - $1\frac{1}{2}$ in.		12.0		12.3
3/4 - 1 in.		7.1		6.3
1/2 - 3/4 in.		6.0		5.5
1/4 - 1/2 in.		6.8		5.5
1/8 - 1/4 in.		3.6		2.9
0 - 1/8 in.		3.9		3.1
Av'g part.size in.	11.330	1.716	5.974	1.805
Size Reduction ....%		15.2		30.2

TABLE IV. Grindability

Screen size of Coal tested	Hardgrove Index*
Mine Run	35.5
0 - $1\frac{1}{2}$ in.	34.5
0 - 1/2 in.	35.2

*See appendix

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb	Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8"	16.0	7.8	36.5	55.7	0.5	12365	2120	2270	2380	260	150	110
4 - 8"	15.8	8.9	37.0	54.1	0.5		2120	2300	2420	300	180	120
2 - 4"	15.6	10.3	36.4	53.3	0.5		2110	2250	2370	260	140	120
1½ - 2"	15.9	10.0	35.8	54.2	0.5		2110	2210	2350	240	100	140
1 - 1½"	15.5	11.4	35.7	52.9	0.5		2120	2220	2400	280	100	180
3/4 - 1"	15.5	11.4	35.1	53.5	0.4		2130	2240	2420	290	110	180
1/2 - 3/4"	15.9	12.5	35.2	52.3	0.4		2130	2270	2370	240	140	100
1/4 - 1/2"	16.1	12.4	34.6	53.0	0.4		2130	2250	2420	290	120	170
1/8 - 1/4"	15.4	14.1	34.6	51.3	0.4		2100	2200	2310	210	100	110
#48 - 1/8"	13.8	19.8	33.0	47.2	0.4		2100	2220	2380	280	120	160
0 - #48	10.3	26.8	31.5	41.7	0.4		2110	2250	2370	260	140	120
Mine Run	15.6	8.6	35.9	55.5	0.5	12150	2100	2220	2340	240	120	120
Plus 1½"	15.5	8.2	36.7	55.1	0.5	12190	2010	2210	2360	350	200	150
0 - 1½"	15.9	12.6	34.8	52.6	0.5	11420	2110	2200	2350	240	90	150
1/2 - 1½"	15.4	11.7	35.2	53.1	0.5	11570*	2110	2220	2380	270	110	160
0 - 1/2"	15.1	14.9	34.0	51.1	0.4	11140*	2110	2240	2350	240	130	110

*Calculated

Classification of Coal By Rank

Specific Volatile Index	117 - Black lignite
A.S.T.M. Classification	Subbituminous B

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	57.7	4.0	0.4	1.2	13.9	7.2	15.6
Dry Basis	68.4	4.8	0.5	1.4	16.3	8.6	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	51.2	4.7	20.7	8.7	2.4	0.2	4.6	0.4	1.5	0.4	6.0	100.52

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "Swelling" Index Test ($1\frac{1}{2}$" Slack)

   Swelling Index . . . . -175
   Section on Coke Classification Chart . . . XIII
   Physical Properties of By-Product Coke . . NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

   Gray Caking Index . . . . NON-CAKING

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$" Slack
- Ash -

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.33	52.1	4.4	52.1	4.4	100.0	13.5	1.40	94.6
Sinks 1.33 " 1.40	33.2	8.5	85.3	6.0	47.9	23.4	1.45	13.9
" 1.40 " 1.50	3.6	20.4	88.9	6.6	14.6	57.4	1.55	2.3
" 1.50 " 1.60	0.8	40.8	89.7	6.9	11.1	68.8	1.65	1.5
" 1.60	10.3	71.0	100.0	13.5	10.3	71.0		
Curve No. 4		2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1 - 1/2 Inch Slack

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	4.9	40.7	54.4	N.A.*	0.5	1970	2040	2180	210	70	140
Sinks 1.33 " 1.40	9.6	38.6	51.8	"	0.4	2190	2250	2410	220	60	160
" 1.40 " 1.50	22.4	34.2	43.4	"	0.4	2130	2250	2360	230	120	110
" 1.50 " 1.60	44.0	26.0	30.0	"	0.3	2130	2280	2390	260	150	110
" 1.60	77.0	16.7	6.3	"	0.1	2140	2270	2370	230	130	100

*Non-agglomerate

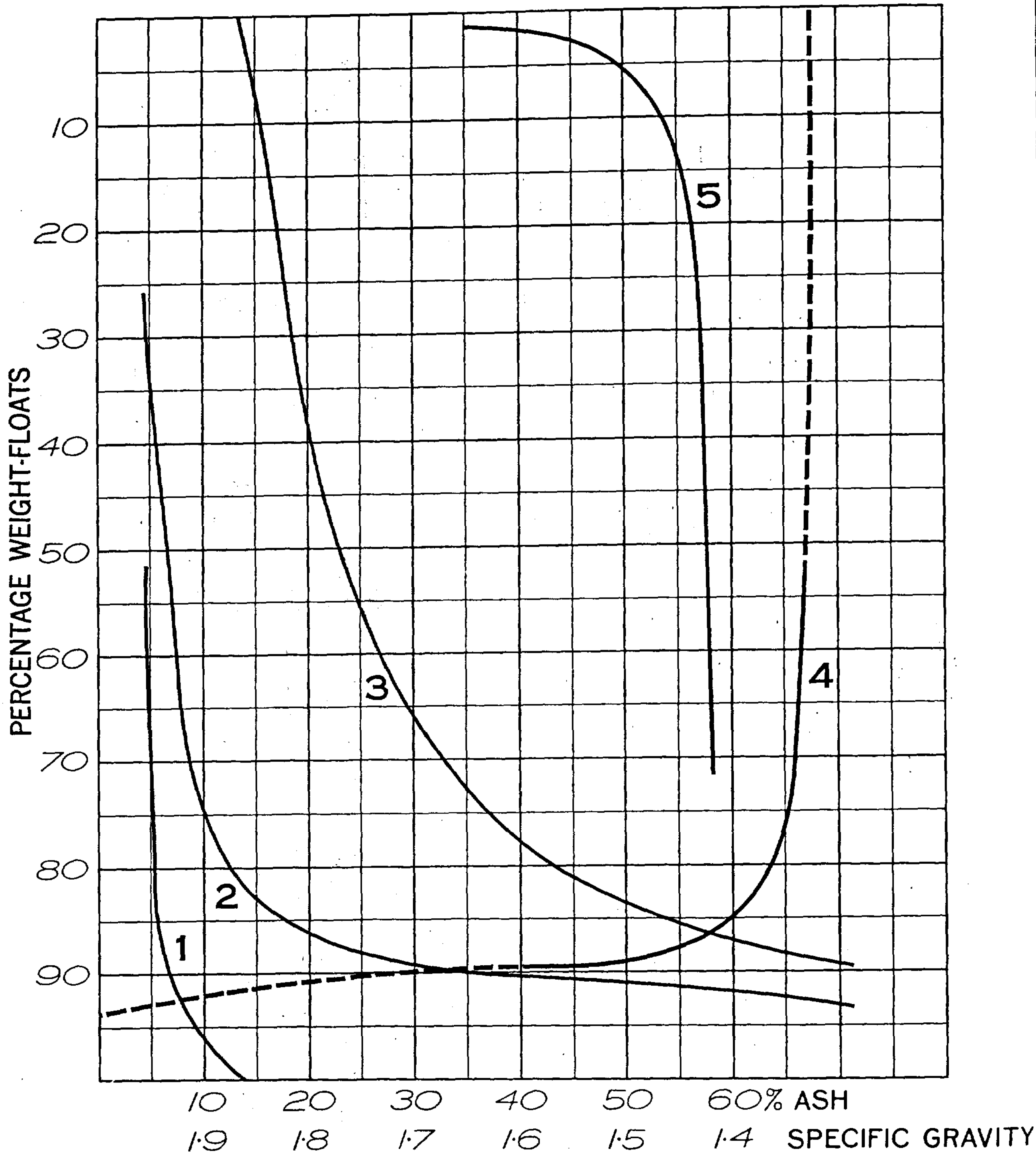

Figure 3 - Washability Curves for 1½ in. slack - No.1 seam, Red Deer Valley Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump
- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash
	%	%	%	%	%	%
Floats 1.33	52.1	5.0	52.1	5.0	100.0	9.1
Sinks 1.33 " 1.40	44.0	8.7	96.1	6.7	47.9	13.5
" 1.40 " 1.50	0.7	28.4	96.8	6.9	3.9	67.4
" 1.60	3.2	75.9	100.0	9.1	3.2	75.9
Curve No.	4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump (Crushed)
- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash
	%	%	%	%	%	%
Floats 1.33	55.50	4.8	55.50	4.8	100.00	6.8
Sinks 1.33 " 1.40	42.90	8.5	98.40	6.4	45.50	9.4
" 1.40 " 1.50	1.08	23.9	99.48	6.6	1.60	32.4
" 1.50 " 1.60	0.07	26.2	99.52	6.6	0.52	50.0
" 1.60	0.48	52.0	100.00	6.8	0.48	52.0
Curve No.	4	2	1,2,4	1	3	3

NO. 1 SEAM -- RED DEER VALLEY MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse
0 to 1½ Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight ....%	100.0	91.8	8.2
Proximate Analysis (Dry Basis)			
Ash ....%	12.6	7.3	73.6
Volatile matter ....%	34.8	35.6	16.0
Fixed carbon ....%	52.6	57.1	10.4
Sulphur ....%	0.5	0.5	0.1
Calorific Value ..........B.T.U./lb	11,420	12,265	2,350
Fusion Point of Ash ....°F.	2,200	2,100	2,320
Melting Range of Ash ....°F.	240	170	440
Coking Properties	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1½ inch	67.8	67.8	11.7	0.5	2220	93.3	7.6	2170	6.7	80.4	2300
0 - 1/2 inch	32.2	100.0	14.9	0.4	2240	90.3	7.2	2160	9.7	72.4	2320

DRUMHELLER DISTRICT
NO. 1 SEAM
MIDLAND NO. 2 MINE, MIDLAND COAL MINING CO. LTD.
MIDLANDVALE, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by Weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs.per cu.ft.	Ash
Plus 8 in.	16.8	16.8	1.34	52.4	8.2
4 - 8 in.	32.6	49.4	1.37	51.6	9.7
2 - 4 in.	18.2	67.6	1.38	46.8	12.6
1½ - 2 in.	5.8	73.4	1.39	46.3	14.6
1 - 1½ in.	8.1	81.5	1.40	45.3	15.0
3/4 - 1 in.	3.6	85.1	1.40	44.2	12.6
1/2 - 3/4 in.	4.5	89.6	1.41	44.5	13.3
1/4 - 1/2 in.	4.9	94.5	1.41	43.5	13.8
1/8 - 1/4 in.	2.6	97.1	1.43	40.7	16.7
#48 - 1/8 in.	2.3	99.4	1.47 (both sizes)	47.1 (both sizes)	21.3
0 - #48	0.6	100.0			30.1
Mine Run		100.0		58.9	12.6
Plus 1½ in.		73.4			10.0
0 - 1½ in.		26.6		50.8	15.2
1/2 - 1½ in.		16.2		46.3	14.0
0 - 1/2 in.		10.4		46.8	17.4

	As Received
Average Size of Run-of-Mine ....in.	4.494

*All screens 1/8 in. and larger are round-hole screens.
No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 in.: Before Test	After 2 Drops	After 4 Drops
2 - 3 in.	100.0	66.0	53.5
1½ - 2 in.		12.5	17.0
1 - 1½ in.		10.5	11.5
3/4 - 1 in.		3.5	5.0
1/2 - 3/4 in.		3.0	4.0
0 - 1/2 in.		4.5	9.0
Av'g Size in.	2.50	2.06	1.87
Size Stability %		82.4	74.8

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE III. Crushing Tests
(Crusher set at 1½ inch)

Size Crushed Screen Sizes	Plus 8 inch Lump Screen Analysis Before Crushing %	Plus 8 inch Lump Screen Analysis After Crushing %	4-8 inch Lump Screen Analysis Before Crushing %	4-8 inch Lump Screen Analysis After Crushing %
12 - 14 in.	8.3			
10 - 12 in.	44.6			
8 - 10 in.	47.1			
7 - 8 in.			19.6	
6 - 7 in.			32.5	
5 - 6 in.			26.4	
4 - 5 in.			21.5	0.5
3 - 4 in.		3.7		2.8
2 - 3 in.		31.5		38.2
1½ - 2 in.		17.8		18.4
1 - 1½ in.		13.6		14.1
3/4 - 1 in.		8.4		7.0
1/2 - 3/4 in.		7.0		6.0
1/4 - 1/2 in.		8.2		6.5
1/8 - 1/4 in.		4.4		3.3
0 - 1/8 in.		5.4		3.2
Av'g part.size in.	10.224	1.560	6.003	1.704
Size Reduction %		15.3		28.4

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove Index*
Mine Run	35.9
0 - 1½ in.	37.3
0 - 1/2 in.	36.9

* See Appendix

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as Rec'd) %	Dry Basis					Initial Deformation °F.	Softening Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb						
Plus 8 in.	15.1	8.2	37.0	54.8	0.5	12,100	1940	2050	2250	310	110	200
4 - 8 in.	15.5	9.7	32.9	57.4	0.5		2160	2260	2420	260	100	160
2 - 4 in.	14.9	12.6	34.7	52.7	0.5		2100	2200	2320	220	100	120
1½ - 2 in.	15.1	14.6	33.8	51.6	0.5		2100	2300	2480	380	200	180
1 - 1½ in.	15.5	15.0	34.0	51.0	0.5		2080	2270	2500	420	190	230
3/4 - 1 in.	15.0	12.6	34.7	52.7	0.5		2060	2230	2410	350	170	180
1/2 - 3/4 in.	15.2	13.3	36.2	50.5	0.5		2100	2250	2420	320	150	170
1/4 - 1/2 in.	15.4	13.8	34.9	51.3	0.5		2150	2270	2450	300	120	180
1/8 - 1/4 in.	15.1	16.7	32.4	50.9	0.5		2200	2300	2460	260	100	160
#48 - 1/8 in.	13.0	21.3	32.2	46.5	0.5		2230	2333	2480	250	100	150
0 - #48	6.9	30.1	28.9	41.0	0.5		2280	2350	2440	160	70	90
Mine Run	14.9	12.6	35.0	52.4	0.5	11,435	2020	2280	2450	430	260	170
Plus 1½ in.	15.2	10.0	35.6	54.4	0.5	11,795	2160	2250	2370	210	90	120
0 - 1½ in.	16.0	15.2	34.0	50.8	0.5	11,000*	2250	2320	2420	170	70	100
1/2 - 1½ in.	15.4	14.0	34.1	51.9	0.5	11,135	2120	2260	2420	300	140	160
0 - 1/2 in.	15.3	17.4	33.8	48.8	0.5	10,690	2020	2300	2440	420	280	140

*Calculated

Classification of Coal by Rank

Specific Volatile Index	113-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE VI. Ultimate Analyses
(Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	54.6	3.6	0.4	1.1	12.2	10.4	17.7
Dry Basis	66.4	4.4	0.5	1.3	14.8	12.6	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	48.4	9.6	20.1	8.8	2.0	0.1	2.4	0.5	0.6	0.4	5.2	98.1

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "Swelling" Index Test 1½" Slack

   Swelling Index . . . . -190
   Section on Coke Classification Chart . XIII
   Physical Properties of By-Product Coke NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

   Gray Caking Index . . . . NON-CAKING

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE IX. Float and Sink Data on 1½" Slack
- Ash -
(As Received Basis)

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution: Gravity	±.10 Specific Gravity Distribution: Calculated Ordinate
Floats 1.33	44.3	4.1	44.3	4.1	100.0	12.4	1.40	93.5
Sinks 1.33 " 1.40	38.0	7.0	82.3	5.4	55.7	19.1	1.45	20.2
" 1.40 " 1.50	5.6	18.0	87.9	6.2	17.7	45.0	1.55	4.2
" 1.50 " 1.60	2.3	29.6	90.2	6.8	12.1	57.5	1.65	2.2
" 1.60	9.8	64.0	100.0	12.4	9.8	64.0	1.75	2.0
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	4.8	36.5	58.7	N.A.*	0.5	1950	2000	2150	200	50	150
Sinks 1.33 " 1.40	8.2	36.1	55.7	"	0.5	2060	2160	2220	160	100	60
" 1.40 " 1.50	20.5	32.9	46.6	"	0.6	2210	2310	2400	190	100	90
" 1.50 " 1.60	33.2	29.2	37.6	"	0.5	2420	2500	2540	120	80	40
" 1.60	71.3	16.7	12.0	"	0.2	2520	2630	2700	180	110	70

*Non-agglomerate

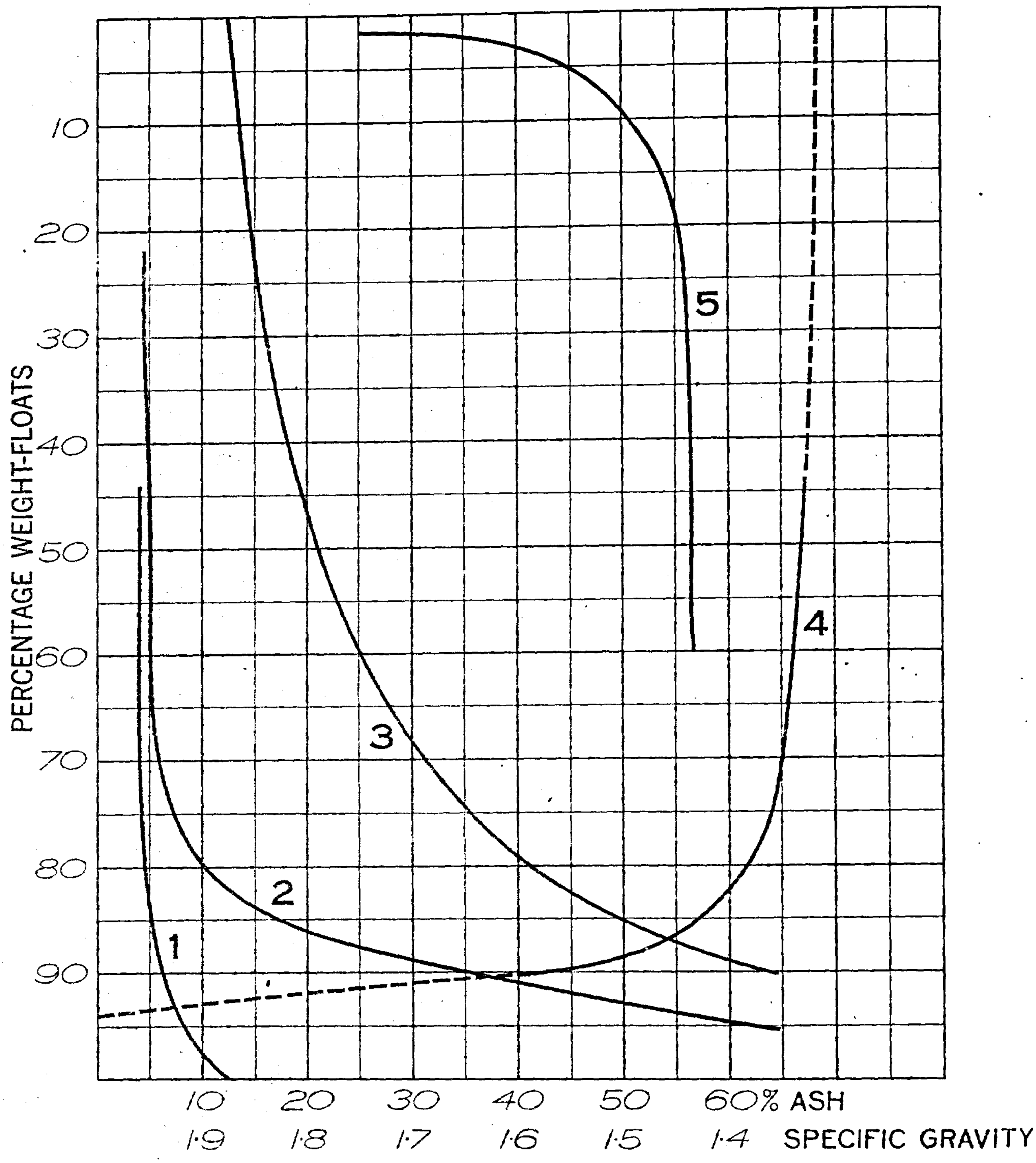

Figure 4 - Washability Curves for 1½ in. slack - No.1 seam, Midland No.2 Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump
- ash -

Specific Gravity			Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats	1.33	40.7	4.8	40.7	4.8	100.0	10.0
Sinks 1.33	"	1.40	47.6	8.1	88.3	6.6	59.3	13.5
" 1.40	"	1.50	7.7	22.1	96.0	7.8	11.7	35.4
" 1.50	"	1.60	1.1	33.8	97.1	8.1	4.0	61.1
" 1.60			2.9	71.4	100.0	10.0	2.9	71.4
Curve No.			4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump (Crushed)
- Ash -

Specific Gravity			Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats	1.33	29.0	4.4	29.0	4.4	100.0	9.0
Sinks 1.33	"	1.40	55.8	7.3	84.8	6.3	71.0	10.9
" 1.40	"	1.50	12.1	20.9	96.9	8.1	15.2	24.0
" 1.50	"	1.60	2.8	34.7	99.7	8.9	3.1	36.2
" 1.60			0.3	50.4	100.0	9.0	0.3	50.4
Curve No.			4	2	1,2,4	1	3	3

NO. 1 SEAM -- MIDLAND NO. 2 MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal, and Refuse
0 to 1½ inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight ...%	100.0	88.5	11.5
Proximate Analysis (Dry Basis)			
Ash ...%	13.6 (a)	7.5	60.7
Volatile Matter ...%	34.6	37.0	21.5
Fixed Carbon ...%	51.8	55.5	17.8
Sulphur ...%	0.5	0.5	0.3
Calorific Value ...Btu/lb.	11,095	11,880	4,200
Fusion Point of Ash...°F.	2,320	2,150	2,850+
Melting Range of Ash ...°F.	170	280	150+
Coking Properties ...	N.A.*	N.A.*	N.A.*

(a) Calculated
* Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1½ in.	60.9	60.9	14.0	0.5	2260	89.0	7.7	2140	11.0	65.5	2660
0 - 1/2 in.	39.1	100.0	17.4	0.5	2300	82.9	7.0	2090	17.1	63.3	2700

DRUMHELLER DISTRICT
NO. 1 SEAM
COMMANDER COAL MINE, REGAL COAL CO. LTD.
DRUMHELLER, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by Weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in.	30.7	30.7	1.38	51.6	7.7
4 - 8 in.	32.6	63.3	1.35	48.3	9.4
2 - 4 in.	14.2	77.5	1.35	45.5	10.1
1½ - 2 in.	3.5	81.0	1.35	43.3	11.5
1 - 1½ in.	5.3	86.3	1.36	43.3	12.9
3/4 - 1 in.	2.8	89.1	1.37	42.4	13.9
1/2 - 3/4 in.	3.2	92.3	1.36	41.8	12.8
1/4 - 1/2 in.	3.6	95.9	1.36	41.0	11.6
1/8 - 1/4 in.	2.0	97.9	1.36	41.2	12.1
#48 - 1/8 in.	1.6	99.5	1.37	48.4	14.0
0 - #48	0.5	100.0			17.9
Mine Run		100.0		58.6	9.6
Plus 1½ in.		81.0			9.2
0 - 1½ in.		19.0		50.5	12.1
1/2 - 1½ in.		11.3		45.3	13.1
0 - 1/2 in.		7.7		47.6	12.7

	As Received
Average size of Run-of-Mine	5.872

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 in.: Before test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	46.5	30.5
1½ - 2 in.		17.0	18.0
1 - 1½ in.		15.0	18.5
3/4 - 1 in.		6.5	9.0
1/2 - 3/4 in.		6.0	8.0
0 - 1/2 in.		9.0	16.0
Av'g size in.	2.50	1.77	1.48
Size stability %		70.8	59.2

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE III. Crushing Tests
(Crusher set at 1½ inch)

Size Crushed Screen Sizes	Plus 8 inch Lump Screen Analysis		4-8 inch Lump Screen Analysis	
	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
12 - 14 in.	22.5			
10 - 12 in.	41.7			
8 - 10 in.	35.8			
7 - 8 in.			23.6	
6 - 7 in.			30.4	
5 - 6 in.			20.5	
4 - 5 in.			25.5	1.3
3 - 4 in.		4.9		4.4
2 - 3 in.		36.8		35.4
1½ - 2 in.		15.8		20.3
1 - 1½ in.		13.1		13.0
3/4 - 1 in.		6.8		7.1
1/2 - 3/4 in.		6.9		6.3
1/4 - 1/2 in.		7.5		6.2
1/8 - 1/4 in.		4.1		3.1
0 - 1/8 in.		4.1		2.9
Av'g particle size	10.734	1.674	6.021	1.748
Size reduction ..%		15.6		29.0

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove Index*
Mine Run	42.8
0 - 1½ in.	42.5
0 - 1/2 in.	42.1

*See Appendix

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd)	Dry Basis					Initial deformation	Softening temperature	Fluid temperature	Melting Range	Softening Interval	Flow interval
		Ash	Volatile Matter	Fixed Carbon	Sulphur	Calorific Value						
	%	%	%	%	%	Btu/lb.	°F.	°F.	°F.	°F.	°F.	°F.
Plus 8 in.	14.5	7.7	36.9	55.4	0.4	12160	1900	2000	2130	230	100	130
4 - 8 in.	13.5	9.4	37.2	53.4	0.4		2150	2230	2260	110	80	30
2 - 4 in.	12.8	10.1	35.9	54.0	0.4		2200	2300	2350	150	100	50
1½ - 2 in.	11.2	11.5	36.7	51.8	0.4		2180	2270	2330	150	90	60
1 - 1½ in.	13.0	12.9	36.8	50.3	0.4		2230	2320	2390	160	90	70
3/4 - 1 in.	13.0	13.9	36.1	50.0	0.4		2150	2250	2320	170	100	70
1/2 - 3/4 in.	14.3	12.8	35.4	51.8	0.4		2190	2260	2320	130	70	60
1/4 - 1/2 in.	13.1	11.6	36.5	51.9	0.4		2100	2290	2320	220	190	30
1/8 - 1/4 in.	13.9	12.1	36.1	51.8	0.4		2190	2310	2360	170	120	50
#48 - 1/8 in.	10.7	14.0	35.5	50.5	0.4		2100	2190	2330	230	90	140
0 - #48	5.3	17.9	34.1	48.0	0.4		2070	2170	2440	370	100	270
Mine Run	13.8	9.6	37.0	53.4	0.4	11840	2070	2150	2220	150	80	70
Plus 1½ in.	13.7	9.2	36.9	53.9	0.4	11870	2120	2200	2360	240	80	160
0 - 1½ in.	14.3	12.1	34.7	53.2	0.4	11405	2300	2370	2460	160	70	90
1/2 - 1½ in.	14.5	13.1	36.2	50.7	0.4	11445*	2200	2285	2355	155	85	70
0 - 1/2 in.	14.0	12.7	36.0	51.3	0.4	11315	2210	2310	2400	190	100	90

*Calculated

Classification of Coal by Rank

Specific Volatile Index	113-Black lignite
A.S.T.M. Classification	Subbituminous B

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	59.7	4.0	0.3	1.1	12.9	8.2	13.8
Dry Basis	69.3	4.7	0.4	1.3	14.7	9.6	.

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	42.9	15.0	21.2	8.3	2.3	0.3	3.5	1.6	1.6	0.4	3.0	100.1

TABLE VIII. Swelling and Caking Properties

I. Coking Properties by "Swelling" Index Test ($1\frac{1}{2}$" slack)

Swelling Index	-180
Section on Coke Classification Chart ..	XIII
Physical Properties of By-Product Coke.	NON-COKING

II. Caking Properties by Gray's Method (Mine Run)

Gray Caking Index	NON-CAKING

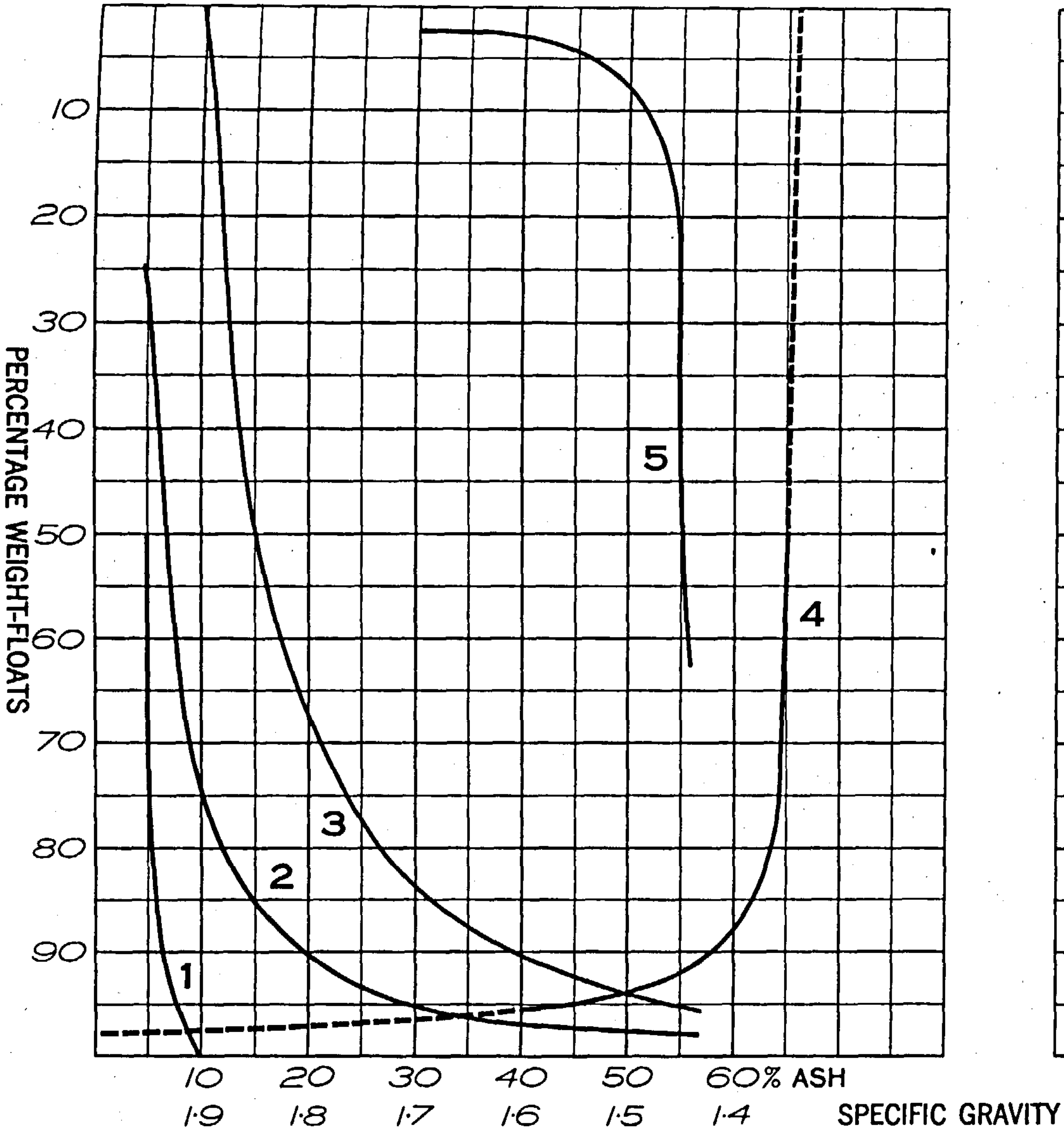

Figure 5 - Washability Curves for 1½ in. Slack - No.1 Seam Commander Coal Mine.

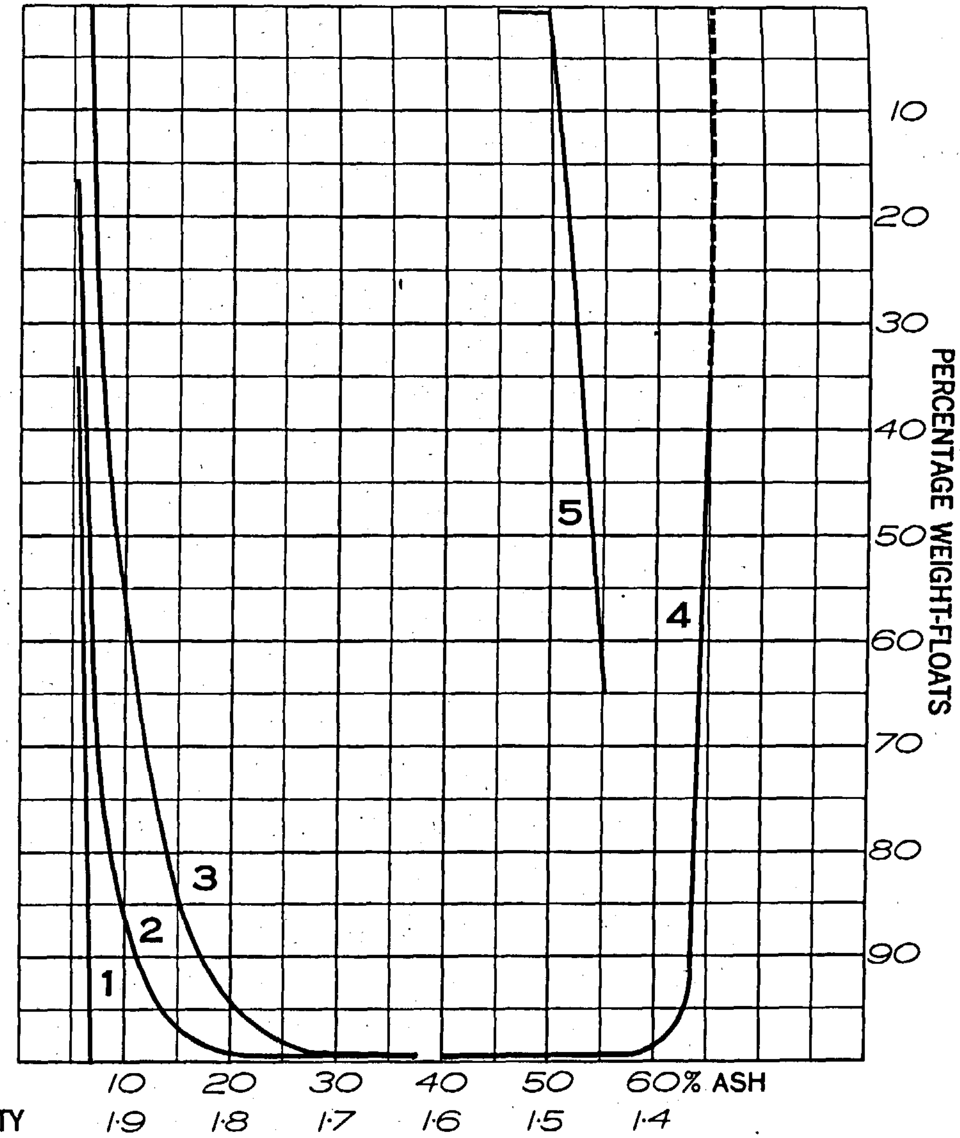

Figure 6 - Washability Curves for Plus 4 in.Lump (Crushed) - No.1 Seam Commander Coal Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .1C Specific gravity distribution.

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE IX. Float and Sink Data on 1½" Slack
- Ash -

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution: Gravity	±.10 Specific Gravity Distribution: Calculated Ordinate
Floats 1.35	50.5	4.9	50.5	4.9	100.0	9.9	1.40	95.8
Sinks 1.35 " 1.40	37.6	8.3	88.1	6.4	49.5	15.0	1.45	45.1
" 1.40 " 1.50	5.3	20.2	93.4	7.1	11.9	36.3	1.50	7.2
" 1.50 " 1.60	1.7	28.8	95.1	7.5	6.6	49.2	1.55	3.8
" 1.60	4.9	56.3	100.0	9.9	4.9	56.3	1.65	2.6
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack
(Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed carbon %	Coking Properties	Sulphur %	Initial deformation °F.	Softening point °F.	Fluid temperature °F.	Melting range °F.	Softening interval °F.	Flow interval °F.
Floats 1.35	5.7	37.5	56.8	Non-agglomerate	0.5	1980	2080	2130	150	100	50
Sinks 1.35 " 1.40	9.5	35.9	54.6	Non-agglomerate	0.4	2070	2300	2380	310	230	80
" 1.40 " 1.50	21.9	32.9	45.2	Non-agglomerate	0.4	2100	2240	2470	370	140	230
" 1.50 " 1.60	31.0	31.3	37.7	Non-agglomerate	0.4	2100	2270	2490	390	170	220
" 1.60	59.6	22.6	17.8	Non-agglomerate	0.3	2360	2470	2540	180	110	70

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE XI. Float and Sink Data on $1\frac{1}{2}$-4 in. Lump
- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats		Cumulative Sinks	
			Weight	Ash	Weight	Ash
	%	%	%	%	%	%
Floats 1.35	19.7	5.0	19.7	5.0	100.0	7.8
Sinks 1.35 " 1.40	78.0	7.5	97.7	7.0	80.3	8.5
" 1.40 " 1.50	0.0	0.0	97.7	7.0	2.3	40.8
" 1.50 " 1.60	1.5	34.8	99.2	7.4	2.3	40.8
" 1.60	0.8	52.0	100.0	7.8	0.8	52.0
Curve No.	4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump (Crushed)
- Ash -

Specific Gravity	Weight	Ash	Cumulative Floats		Cumulative Sinks		±.10 Specific Gravity Distribution	
			Weight	Ash	Weight	Ash	Gravity	Calculated ordinate
	%	%	%	%	%	%		
Floats 1.35	34.3	5.4	34.3	5.4	100.0	6.8	1.40	99.6
Sinks 1.35 " 1.40	64.6	7.2	98.9	6.6	65.7	7.5	1.45	65.3
" 1.40 " 1.50	0.7	21.2	99.6	6.7	1.1	26.2	1.50	0.6
" 1.50 " 1.60	0.1	28.0	99.7	6.7	0.4	35.1	1.55	0.5
" 1.60 "	0.3	37.4	100.0	6.8	0.3	37.4		
Curve No.	4	2	1,2,4	1	3	3	5	5

NO. 1 SEAM -- COMMANDER COAL MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse 0 to $1\frac{1}{2}$ Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight ....%	100.0	92.2	7.8
Proximate Analysis (Dry Basis)			
Ash ....%	12.1	8.2	61.6
Volatile Matter ....%	34.7	35.4	27.7
Fixed carbon ....%	53.2	56.4	16.7
Sulphur ....%	0.4	0.4	0.2
Calorific Value ....B.t.u./lb.	11405	11955	----
Fusion Point of Ash ....°F.	2370	2090	2440
Melting Range of Ash ....°F.	160	200	320
Coking Properties	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes prepared from $1\frac{1}{2}$ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after washing at a Gravity of 1.50

Screen Sizes	Weight %	Cumu-Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - $1\frac{1}{2}$ in.	59.5	59.5	13.1	0.4	2285	93.3	8.7	2160	6.7	73.5	2700+
0 - 1/2 in.	40.5	100.0	12.7	0.4	2310	92.5	8.1	2220	7.5	57.5	2470

DRUMHELLER DISTRICT
NO. 1 SEAM
HY-GRADE MINE, HY-GRADE COAL MINING CO., LTD.
DRUMHELLER, ALBERTA
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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	25.5	25.5	1.36	54.5	8.4
4 - 8 in..	38.5	64.0	1.36	51.3	8.4
2 - 4 in..	19.2	83.2	1.37	43.9	8.7
1½ - 2 in..	3.5	86.7	1.37	44.0	9.6
1 - 1½ in..	5.4	92.1	1.38	43.8	9.3
3/4 - 1 in..	2.1	94.2	1.38	42.3	9.3
1/2 - 3/4 in..	2.0	96.2	1.38	42.0	9.5
1/4 - 1/2 in..	2.0	98.2	1.38	42.0	10.0
1/8 - 1/4 in..	0.9	99.1	1.38	42.0	12.3
#48 - 1/8 in..	0.7	99.8	1.40		15.4
0 - #48.....	0.2	100.0			23.9
Mine Run		100.0		56.0	9.4
Plus 1½ in..		86.7			8.4
0 - 1½ in..		13.3		48.3	11.6
1/2 - 1½ in..		9.5			9.3
0 - 1/2 in..		3.8			14.1

	As Received
Average Size of Run-of-Mine.....................in.	5.658

*All screens 1/8 in. and larger are round-hole screens. No.48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	59.0	47.0
1½ - 2 in.		16.5	18.0
1 - 1½ in.		11.0	11.5
3/4 - 1 in.		4.5	7.0
1/2 - 3/4 in.		3.5	5.5
0 - 1/2 in.		5.5	11.0
Av'g Size in.	2.50	1.98	1.76
Size Stability %		79.2	70.4

NO. 1 SEAM - HY-GRADE MINE

TABLE III. Crushing Tests
(Crusher set at 1½ inch)

Size Crushed	Plus 8 inch lump		4-8 inch lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
12 - 14 in......	5.1			
10 - 12 in......	34.5			
8 - 10 in......	60.4			
7 - 8 in......			31.2	
6 - 7 in......			28.3	
5 - 6 in......			23.5	
4 - 5 in......		1.2	17.0	1.7
3 - 4 in......		15.5		12.2
2 - 3 in......		32.3		32.9
1½ - 2 in......		14.7		15.2
1 - 1½ in......		11.6		12.4
3/4 - 1 in......		6.4		6.8
1/2 - 3/4 in......		5.5		5.8
1/4 - 1/2 in......		6.1		6.3
1/8 - 1/4 in......		3.3		3.3
0 - 1/8 in......		3.4		3.4
Av'g part.size in.	9.894	1.927	6.238	1.876
Size reduction...%		19.5		30.1

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	35.2
0 - 1-1/2 in..	34.5
0 - 1/2 in..	35.2

* See Appendix

NO. 1 SEAM - HY- GRADE MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	15.7	8.4	36.5	55.1	0.6		1900	2220	2350	450	320	130
4 - 8 in..	15.4	8.4	37.9	53.7	0.6	12,205	1900	2200	2340	440	300	140
2 - 4 in..	15.0	8.7	36.4	54.9	0.5		1900	2210	2360	460	310	150
1½ - 2 in..	14.8	9.6	36.7	53.7	0.6		1900	2220	2350	450	320	130
1 - 1½ in..	14.1	9.3	36.2	54.5	0.6		1900	2210	2360	460	310	150
3/4 - 1 in..	16.3	9.3	35.6	55.1	0.6		1900	2200	2340	440	300	140
1/2 - 3/4 in..	16.6	9.5	37.3	53.2	0.6		1910	2180	2350	440	270	170
1/4 - 1/2 in..	17.1	10.0	37.8	52.2	0.6		1920	2190	2360	440	270	170
1/8 - 1/4 in..	12.3	12.3	36.1	51.6	0.6		1930	2200	2380	450	270	180
#48 - 1/8 in..	11.1	15.4	36.1	48.5	0.5		2100	2280	2450	350	180	170
0 - #48	6.4	23.9	30.7	45.4	0.6		2100	2320	2490	390	220	170
Mine Run....	15.4	9.4	36.5	54.1	0.6	12,065	1900	2220	2350	450	320	130
Plus 1½ in..	15.6	8.4	37.2	54.4	0.6	12,110	1930	2100	2240	310	170	140
0 - 1½ in..	15.8	11.6	35.9	52.5	0.6	11,485	1920	2220	2350	430	300	130
1/2 - 1½ in..	15.3	9.3	36.3	54.4	0.6	12,005*	1920	2210	2340	420	290	130
0 - 1/2 in..	14.8	14.1	36.4	49.5	0.6	11,080	1930	2210	2350	420	280	140

*Recalculated

Classification of Coal by Rank

Specific Volatile Index 118-Black Lignite
A.S.T.M. Classification Subbituminous B

TABLE VI. Ultimate Analyses
(Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	59.4	5.0	0.6	1.2	11.5	7.9	15.4
Dry basis	70.2	4.8	0.6	1.4	13.6	9.4	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	48.0	6.5	21.0	10.6	2.0	0.01	5.1	0.6	1.4	0.3	1.5	97.01

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" slack)

Swelling Index............................	-145
Section on Coke Classification Chart.....	XIII
Physical Properties of by-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index........................	NON-CAKING

NO. 1 SEAM - HY-GRADE MINE

NO. 1 SEAM - HY-GRADE MINE

TABLE IX. Float and Sink Data on 1½ in. Slack

-Ash-

Specific Gravity	Weight %	Ash %	-Ash- Cumulative Floats Weight %	Floats Ash %	Sinks Weight %	Sinks Ash %	±.10 Specific Gravity Distribution Gravity	Calculated Ordinate
Floats 1.33	43.6	4.5	43.6	4.5	100.0	10.0	1.40	95.5
Sinks 1.33 " 1.40	43.9	7.5	87.5	6.0	56.4	14.3	1.45	24.8
" 1.40 " 1.50	5.6	20.9	93.1	6.9	12.5	38.1	1.55	4.4
" 1.50 " 1.60	2.4	33.3	95.5	7.6	6.9	52.1	1.65	2.0
" 1.60	4.5	62.2	100.0	10.0	4.5	62.2	1.75	1.0
Curve No.	4	2	1, 2, 4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack (Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	5.3	39.6	55.1	N.A.*	0.6	2000	2020	2110	110	20	90
Sinks 1.33 Fl" 1.40	8.7	35.7	55.6	N.A.*	0.6	2010	2220	2270	260	110	50
" 1.40 " 1.50	23.6	32.2	44.2	N.A.*	0.6	2000	2350	2500	500	350	150
" 1.50 " 1.60	37.2	28.5	34.3	N.A.*	0.6	2000	2560	2750	750	560	190
" 1.60	68.8	18.6	12.6	N.A.*	0.3	2250	2320	2710	460	70	390

*Non-agglomerate.

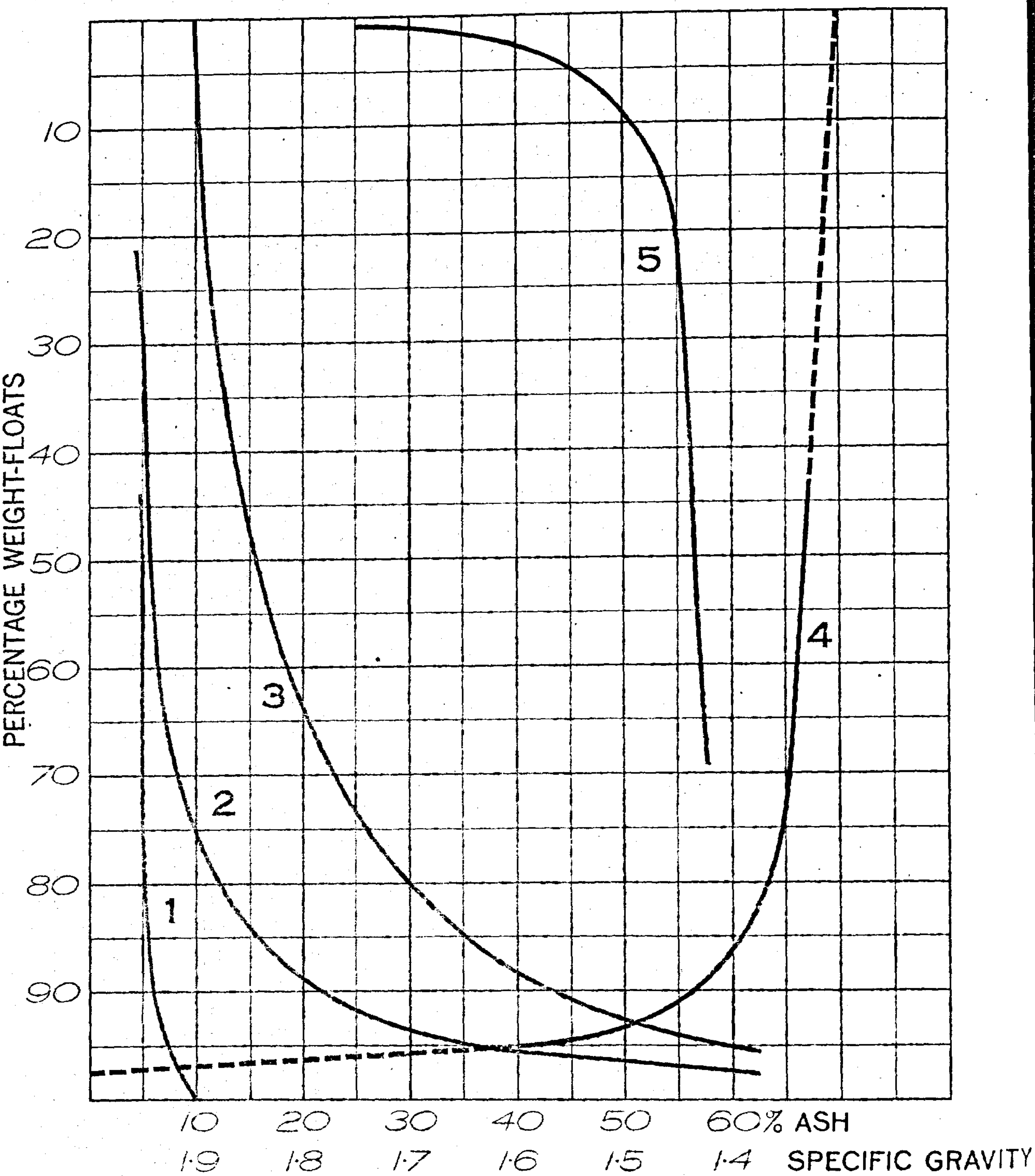

Figure 7 - Washability Curves for 1½ in. slack - No.1 seam, Hy-Grade Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM - HY-GRADE MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	69.7	5.2	69.7	5.2	100.0	7.8
Sinks 1.33	" 1.40	20.8	8.3	90.5	5.9	30.3	13.8
" 1.40	" 1.50	7.6	23.1	98.1	7.2	9.5	25.8
" 1.50	" 1.60	1.7	23.3	99.8	7.7	1.9	36.7
" 1.60	"	0.2	65.2	100.0	7.8	0.2	65.2
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	63.2	5.9	63.2	5.9	100.0	7.8
Sinks 1.33	" 1.40	33.4	10.0	96.6	7.3	36.8	11.1
" 1.40	" 1.50	2.6	19.4	99.2	7.6	3.4	22.2
" 1.50	" 1.60	0.8	31.3	100.0	7.8	0.8	31.3
Curve No.	4	2	2	1, 2, 4	1	3	3

NO. 1 SEAM - HY-GRADE MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight.............................%	100.0	93.8	6.2
Proximate Analysis (dry basis)			
Ash............................%	11.6	8.2	57.1
Volatile matter................%	35.9	37.3	22.6
Fixed carbon...................%	52.5	54.5	20.3
Sulphur........................%	0.6	0.6	0.4
Calorific value.......B.T.U./lb.	11,485	12,000	4,930
Fusion Point of Ash..........°F.	2220	2150	2650
Melting Range of Ash.........°F.	430	340	330
Coking Properties..............:	N.A.*	N.A.*	N.A.*

* Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A °F.
1/2 - 1-1/2 inch	72.0	72.0	9.3	0.6	2210	92.0	8.1	2120	8.0	61.1	2750+
0 - 1/2 inch	28.0	100.0	14.1	0.6	2210	87.0	8.1	2090	13.0	56.7	2410

DRUMHELLER DISTRICT
NO. 1 SEAM
BRILLIANT MINE, BRILLIANT COAL CO.
DRUMHELLER, ALBERTA
---------0---------

TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	15.6	15.6	1.37	57.0	9.9
4 - 8 in..	49.1	64.7	1.37	49.6	11.5
2 - 4 in..	18.1	82.8	1.38	45.0	12.1
1½ - 4 in..	3.6	86.4	1.38	44.0	12.3
1 - 1½ in..	4.4	90.8	1.37	43.6	12.5
3/4 - 1 in..	1.9	92.7	1.38	44.4	11.9
1/2 - 3/4 in..	2.2	94.9	1.37	42.8	12.2
1/4 - 1/2 in..	2.4	97.3	1.37	43.0	13.5
1/8 - 1/4 in..	1.3	98.6	1.38	42.5	13.2
#48 - 1/8 in..	1.2	99.8	1.42	45.0	18.8
0 - #48	0.2	100.0			25.0
Mine Run		100.0		49.0	11.6
Plus 1½ in..		86.4		----	10.9
0 - 1½ in..		13.6		50.5	14.6
1/2 - 1½ in..		8.5		43.2	12.3
0 - 1/2 in..		5.1		44.3	15.0

	As Received
Average Size of Run-of-Mine.................in.	5.26

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	64.0	52.0
1½ - 2 in.		10.5	12.5
1 - 1½ in.		10.5	13.0
3/4 - 1 in.		4.5	5.0
1/2 - 3/4 in.		3.0	6.0
0 - 1/2 in.		7.5	11.5
Av'g Size in.	2.50	1.99	1.75
Size Stability.%		79.6	70.0

NO. 1 SEAM - BRILLIANT MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in......	53.2			
8 - 10 in......	46.8			
7 - 8 in......			29.7	
6 - 7 in......			24.4	
5 - 6 in......			19.1	
4 - 5 in......		0.6	26.8	2.0
3 - 4 in......		10.5		9.1
2 - 3 in......		39.6		40.5
$1\frac{1}{2}$ - 2 in......		12.7		12.4
1 - $1\frac{1}{2}$ in......		13.3		12.9
3/4 - 1 in......		5.8		5.6
1/2 - 3/4 in......		6.0		6.0
1/4 - 1/2 in......		5.8		5.6
1/8 - 1/4 in......		2.9		3.0
0 - 1/8 in......		2.8		2.9
Av'g part.size in.	10.064	1.891	6.071	1.915
Size reduction...%		18.8		31.5

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	36.6
0 - 1-1/2 in..	36.6
0 - 1/2 in..	36.6

* See Appendix

NO. 1 SEAM - BRILLIANT MINE

NO. 1 SEAM - BRILLIANT MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis: Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	15.1	9.9	36.8	53.3	0.5		2160	2260	2440	280	100	180
4 - 8 in..	14.5	11.5	37.1	51.4	0.6	11,680	2150	2260	2460	310	110	200
2 - 4 in..	14.5	12.1	37.2	50.7	0.5		2200	2300	2460	260	100	160
1½ - 2 in..	13.7	12.3	37.5	50.2	0.5		2220	2350	2480	260	130	130
1 - 1½ in..	14.2	12.5	36.7	50.8	0.4		2230	2310	2470	240	80	160
3/4 - 1 in..	14.5	11.9	35.2	52.9	0.4		2220	2320	2410	190	100	90
1/2 - 3/4 in..	14.0	12.2	35.6	52.2	0.5		2210	2320	2410	200	110	90
1/4 - 1/2 in..	14.5	13.5	35.7	50.8	0.5		2220	2300	2420	200	80	120
1/8 - 1/4 in..	12.7	13.2	35.5	51.3	0.5		2220	2310	2430	210	90	120
#48 - 1/8 in..	13.2	18.8	32.8	48.4	0.4		2240	2310	2460	220	70	150
0 - #48	7.5	25.0	32.6	42.4	0.6		2200	2290	2400	200	90	110
Mine Run....	14.9	11.6	37.2	51.2	0.4	11,615	2200	2300	2400	200	100	100
Plus 1½ in..	14.9	10.9	37.6	51.5	0.4	11,670	2210	2310	2410	200	100	100
0 - 1½ in..	15.0	14.6	35.3	50.1	0.5	11,115	2210	2310	2410	200	100	100
1/2 - 1½ in..	14.2	12.3	36.1	51.6	0.4	11,400	2200	2300	2410	210	100	110
0 - 1/2 in..	14.7	15.0	35.6	49.4	0.5	10,965	2250	2340	2460	210	90	120

Classification of Coal by Rank

Specific Volatile Index 116-Black Lignite
A.S.T.M. Classification Subbituminous B

NO. 1 SEAM - BRILLIANT MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	55.0	3.8	0.4	1.1	11.9	9.4	18.4
Dry basis	67.4	4.6	0.4	1.3	14.7	11.6	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	52.5	4.9	22.8	8.5	2.1	0.04	4.0	0.7	1.4	0.4	2.2	99.54

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test ($1\frac{1}{2}$" slack)

Swelling Index............................	-175
Section on Coke Classification Chart.....	XIII
Physical Properties of by-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index.......................	NON-CAKING

NO. 1 SEAM - BRILLIANT MINE

TABLE IX. Float and Sink Data on 1½ in. Slack
-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.32	27.2	5.2	27.2	5.2	100.0	11.3	1.40	96.3
Sinks 1.32 Floats 1.40	56.8	7.7	84.0	6.9	72.8	13.5	1.45	44.6
Sinks 1.40 Floats 1.50	9.6	20.2	93.6	8.3	16.0	34.1	1.55	5.2
Sinks 1.50 Floats 1.60	1.7	31.5	95.3	8.7	6.4	55.1	1.65	1.5
Sinks 1.60	4.7	63.6	100.0	11.3	4.7	63.6	1.75	0.9
Curve No.	4	2	1, 2, 4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack
(Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.32	6.0	38.1	55.9	N.A.*	0.5	2040	2130	2230	190	90	100
Sinks 1.32 Floats 1.40	8.9	38.1	53.0	N.A.*	0.5	2160	2290	2440	280	130	150
Sinks 1.40 Floats 1.50	22.4	32.6	45.0	N.A.*	0.4	2370	2570	2700	330	200	130
Sinks 1.50 Floats 1.60	33.9	29.6	36.5	N.A.*	0.7	2280	2440	2560	280	160	120
Sinks 1.60	68.5	20.1	11.4	N.A.*	0.3	2300	2450	2560	260	150	110

*Non-agglomerate.

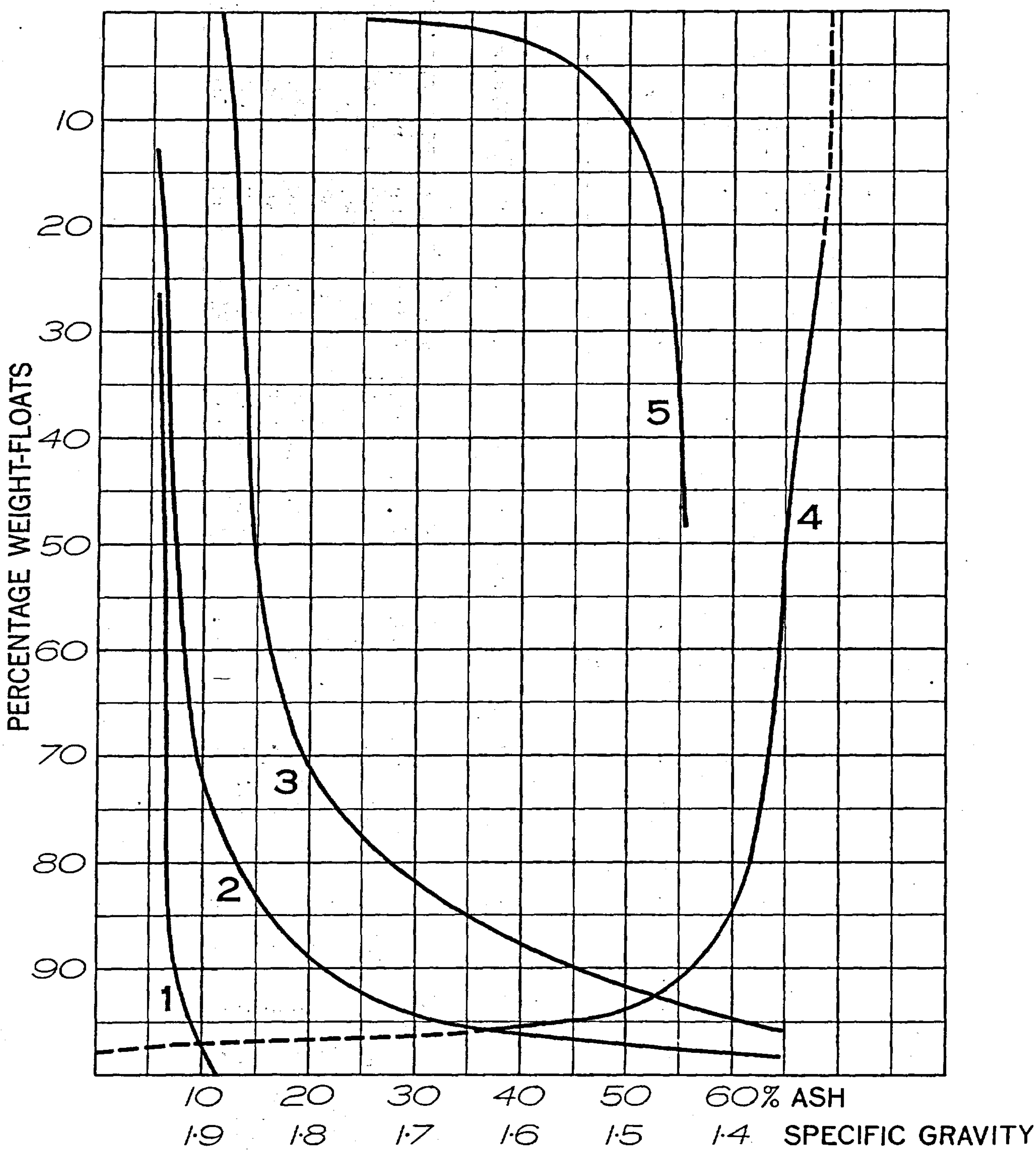

Figure 8 - Washability Curves for 1½ in. slack - No. 1 seam, Brilliant Coal Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM - BRILLIANT MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity		Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats 1.32	33.1	5.2	33.1	5.2	100.0	9.6
Sinks 1.32	" 1.40	48.2	9.0	81.3	7.5	66.9	11.8
" 1.40	" 1.50	17.2	17.3	98.5	9.2	18.7	19.2
" 1.50		1.5	40.8	100.0	9.6	1.5	40.8
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats 1.32	23.2	6.9	23.2	6.9	100.0	10.1
Sinks 1.32	" 1.40	52.4	9.1	75.6	8.4	76.8	11.0
" 1.40	" 1.50	23.3	13.9	98.9	9.7	24.4	15.1
" 1.50		1.1	40.3	100.0	10.1	1.1	40.3
Curve No.	4		2	1, 2, 4	1	3	3

NO. 1 SEAM - BRILLIANT MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight..............................%	100.0	91.5	8.5
Proximate Analysis (dry basis)			
Ash.............................%	14.6	10.5	58.8
Volatile matter.................%	35.3	36.4	22.0
Fixed carbon....................%	50.1	53.1	19.2
Sulphur.........................%	0.5	0.5	0.2
Calorific value.......B.T.U./lb.	11,115	11,500	4,670
Fusion Point of Ash..........°F.	2310	2250	2320
Melting Range of Ash.........°F.	210	260	280
Coking Properties..............:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	62.5	62.5	12.3	0.4	2300	91.5	10.3	2330	8.5	64.6	2150
0 - 1/2 inch	37.5	100.0	15.0	0.5	2340	85.8	8.9	2290	14.2	63.4	2320

DRUMHELLER DISTRICT
NO. 7 SEAM
MINUTE MINE, MINUTE COAL CO.
NORTH DRUMHELLER, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	10.9	10.9	1.36	52.7	17.0
4 - 8 in..	20.8	31.7	1.36	51.1	14.1
2 - 4 in..	21.1	52.8	1.39	45.0	15.5
1½ - 2 in..	5.7	58.5	1.40	45.4	12.7
1 - 1½ in..	11.2	69.7	1.39	44.8	14.4
3/4 - 1 in..	5.6	75.3	1.39	43.5	13.6
1/2 - 3/4 in..	7.1	82.4	1.39	43.3	11.6
1/4 - 1/2 in..	8.1	90.5	1.39	42.8	13.2
1/8 - 1/4 in..	4.4	94.9	1.39	41.5	15.7
#48 - 1/8 in..	4.1	99.0	1.43	46.6	20.5
0 - #48	1.0	100.0			29.8
Mine Run		100.0		54.0	15.8
Plus 1½ in..		58.5			15.8
0 - 1½ in..		41.5		54.3	15.7
1/2 - 1½ in..		23.9		45.0	14.0
0 - 1/2 in..		17.6		48.5	17.7

	As Received
Average Size of Run-of-Mine................in.	3.174

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	56.5	43.5
1½ - 2 in.		14.0	14.0
1 - 1½ in.		10.0	12.5
3/4 - 1 in.		5.0	7.0
1/2 - 3/4 in.		5.5	7.0
0 - 1/2 in.		9.0	16.0
Av'g Size in.	2.50	1.88	1.63
Size Stability.%		75.2	65.2

TABLE III. Crushing Tests
(Crusher set at 1½ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in.....	11.9			
8 - 10 in.....	88.1			
7 - 8 in.....			15.4	
6 - 7 in.....			27.9	
5 - 6 in.....			22.1	
4 - 5 in.....			34.6	
3 - 4 in.....		4.0		4.7
2 - 3 in.....		30.9		29.3
1½ - 2 in.....		17.9		21.4
1 - 1½ in.....		14.3		15.2
3/4 - 1 in.....		8.6		8.3
1/2 - 3/4 in.....		7.4		6.8
1/4 - 1/2 in.....		8.0		7.6
1/8 - 1/4 in.....		4.1		3.4
0 - 1/8 in.....		4.8		3.3
Av'g part.size in.	9.238	1.567	5.742	1.616
Size reduction...%		17.0		28.1

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	36.6
0 - 1-1/2 in..	35.9
0 - 1/2 in..	37.3

* See Appendix

NO. 7 SEAM - MINUTE MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd)	Dry Basis					Initial Deformation	Softening-Temperature	Fluid Temperature	Melting Range	Softening Interval	Flow Interval
	%	Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.	°F.	°F.	°F.	°F.	°F.	°F.
Plus 8 in..	15.0	17.0	33.9	49.1	0.5	10,720	2350	2500	2600	250	150	100
4 - 8 in..	15.8	14.1	34.3	51.6	0.6		2350	2430	2530	180	80	100
2 - 4 in..	15.0	15.5	33.7	50.8	0.5		2250	2310	2430	180	60	120
1½ - 2 in..	15.9	12.7	34.4	52.9	0.6		2280	2370	2460	180	90	90
1 - 1½ in..	15.8	14.4	35.2	50.4	0.6		2270	2330	2460	190	60	130
3/4 - 1 in..	15.1	13.6	34.4	52.0	0.6		2270	2350	2430	160	80	80
1/2 - 3/4 in..	16.0	11.6	35.1	53.3	0.6		2250	2300	2420	170	50	120
1/4 - 1/2 in..	16.5	13.2	34.5	52.3	0.6		2200	2300	2500	300	100	200
1/8 - 1/4 in..	14.7	15.7	34.7	49.6	0.6		2220	2330	2530	310	110	200
#48 - 1/8 in..	12.5	20.5	31.7	47.8	0.5		2280	2390	2460	180	110	70
0 - #48	4.7	29.8	28.9	41.3	0.5		2230	2330	2540	310	100	210
Mine Run....	15.3	15.8	33.9	50.3	0.6	10,820	2230	2420	2520	290	190	100
Plus 1½ in..	15.6	15.8	34.7	49.5	0.6	10,940	2310	2380	2500	190	70	120
0 - 1½ in..	15.5	15.7	34.3	50.0	0.5	10,885	2200	2370	2530	330	170	160
1/2 - 1½ in..	15.3	14.0	34.9	51.1	0.5	11,085	2230	2330	2520	290	100	190
0 - 1/2 in..	15.1	17.7	32.5	49.8	0.5	10,555	2230	2360	2540	310	130	180

Classification of Coal by Rank

Specific Volatile Index 108-Black Lignite

A.S.T.M. Classification Subbituminous B

NO. 7 SEAM - MINUTE MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	53.8	3.7	0.5	0.9	12.4	13.4	15.3
Dry basis	63.4	4.4	0.6	1.1	14.7	15.8	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	55.5	3.6	22.8	6.1	0.5	0.1	3.0	1.7	0.3	0.8	4.1	98.5

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" slack)

Swelling Index............................	-200
Section on Coke Classification Chart.....	XIII
Physical Properties of by-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index.........................	NON-CAKING

NO. 7 SEAM - MINUTE MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$ in. Slack

Specific Gravity		Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
		%	-Ash- %	%	%	%	%		
Floats	1.33	48.0	3.8	48.0	3.8	100.0	12.9	1.40	94.2
Sinks 1.33 "	1.40	28.3	8.4	76.3	5.5	52.0	21.3	1.45	31.4
" 1.40 "	1.50	12.9	22.4	89.2	7.9	23.7	36.7	1.55	8.7
" 1.50 "	1.60	3.6	30.6	92.8	8.8	10.8	53.8	1.65	1.5
" 1.60 "		7.2	65.4	100.0	12.9	7.2	65.4	1.75	0.7
Curve No.	4		2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of $1\frac{1}{2}$" Slack (Dry Basis)

Specific Gravity		Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats	1.30	4.4	38.4	57.2	N.A.*	0.6	1950	2080	2140	190	130	60
Sinks 1.30 "	1.40	9.7	36.1	54.2	N.A.*	0.6	2150	2250	2420	270	100	170
" 1.40 "	1.50	25.2	31.1	43.7	N.A.*	0.6	2450	2600	2680	230	150	80
" 1.50 "	1.60	33.7	28.3	38.0	N.A.*	0.4	2460	2630	2730	270	170	100
" 1.60		69.1	17.2	13.7	N.A.*	0.2	2340	2450	2700	360	110	250

*Non-agglomerate.

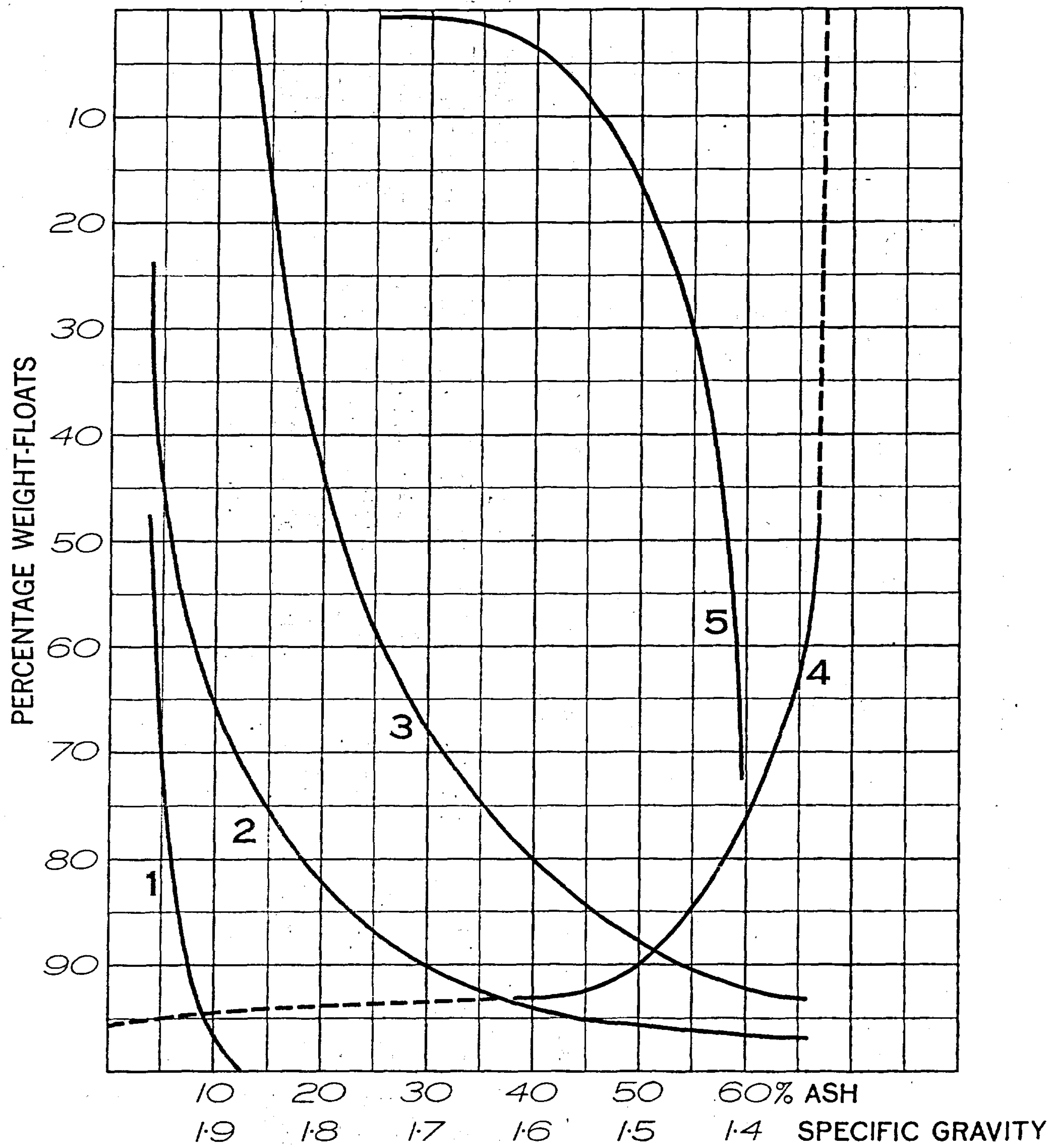

Figure 9 - Washability Curves for 1½ in. slack - No. 7 seam, Minute Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 7 SEAM - MINUTE MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity		Weight	Ash	Cumulative			
				Floats		Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	59.3	3.7	59.3	3.7	100.0	9.4
Sinks 1.33	" 1.40	15.4	9.5	74.7	4.9	40.7	17.7
" 1.40	" 1.50	23.7	22.3	98.4	9.1	25.3	22.7
" 1.50	" 1.60	1.6	29.4	100.0	9.4	1.6	29.4
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight	Ash	Cumulative			
				Floats		Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	26.8	3.8	26.8	3.8	100.0	12.3
Sinks 1.33	" 1.40	44.4	9.6	71.2	7.4	73.2	15.4
" 1.40	" 1.50	22.6	22.0	93.8	10.9	28.8	24.5
" 1.50	" 1.60	5.0	30.6	98.8	11.9	6.2	33.4
" 1.60		1.2	45.1	100.0	12.3	1.2	45.1
Curve No.	4		2	1, 2, 4	1	3	3

NO. 7 SEAM - MINUTE MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.55	Refuse Sinks 1.55
Weight ....%	100.0	90.7	9.3
Proximate Analysis (dry basis)			
Ash ....%	14.0(a)	8.7	65.0
Volatile Matter ....%	35.2	35.1	18.6
Fixed carbon ....%	50.8	56.2	16.4
Sulphur ....%	0.6	0.6	0.3
Calorific Value.......B.T.U./lb.	11,000	11,665	3,935
Fusion Point of Ash...........°F.	2370	2300	2530
Melting Range of Ash..........°F.	330	280	380
Coking Properties	N.A.*	N.A.*	N.A.*

*Non-agglomerate
(a) Calculated

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	57.6	57.6	14.0	0.5	2330	94.0	8.4	2220	6.0	63.0	2740
0 - 1/2 inch	42.4	100.0	17.7	0.5	2360	81.8	8.5	2150	18.2	63.6	2420

ROSEDALE DISTRICT
NO. 1 SEAM
STAR MINE, ROSEDALE COLLIERIES LTD.
ROSEDALE, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	24.1	24.1	1.35	52.5	9.2
4 - 8 in..	38.2	62.3	1.34	49.2	9.3
2 - 4 in..	18.9	81.2	1.35	45.2	9.1
1½ - 2 in..	4.2	85.4	1.35	44.3	8.6
1 - 1½ in..	4.9	90.3	1.36	43.9	9.8
3/4 - 1 in..	2.1	92.4	1.36	45.0	9.7
1/2 - 3/4 in..	2.6	95.0	1.36	42.9	11.0
1/4 - 1/2 in..	2.6	97.6	1.36	42.3	11.4
1/8 - 1/4 in..	1.1	98.7	1.37	37.2	12.9
#48 - 1/8 in..	1.1	99.8	1.39	42.5	14.8
0 - #48	0.2	100.0			20.8
Mine Run		100.0		55.6	10.1
Plus 1½ in..		85.4			8.8
0 - 1½ in..		14.6		48.5	11.5
1/2 - 1½ in..		9.6		46.1	10.1
0 - 1/2 in..		5.0		41.2	12.7

	As Received
Average Size of Run-of-Mine...............in.	5.51

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	63.0	46.5
1½ - 2 in.		12.0	15.0
1 - 1½ in.		11.0	15.5
3/4 - 1 in.		5.0	6.5
1/2 - 3/4 in.		3.5	5.0
0 - 1/2 in.		5.5	11.5
Av'g Size in.	2.50	2.00	1.74
Size Stability.%		80.0	69.6

NO. 1 SEAM - STAR MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
12 - 14 in.....	26.6			
10 - 12 in.....	31.5			
8 - 10 in.....	41.9			
7 - 8 in.....			17.8	
6 - 7 in.....			22.3	
5 - 6 in.....			23.8	
4 - 5 in.....			36.1	
3 - 4 in.....		3.2		5.0
2 - 3 in.....		32.8		38.7
$1\frac{1}{2}$ - 2 in.....		15.2		18.4
1 - $1\frac{1}{2}$ in.....		12.4		12.3
3/4 - 1 in.....		7.9		6.7
1/2 - 3/4 in.....		7.9		6.1
1/4 - 1/2 in.....		8.8		6.4
1/8 - 1/4 in.....		5.3		3.2
0 - 1/8 in.....		6.5		3.2
Av'g part.size in.	10.694	1.519	5.718	1.746
Size reduction...%		14.2		30.5

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	36.9
0 - 1-1/2 in..	33.4
0 - 1/2 in..	33.8

*See Appendix

NO. 1 SEAM - STAR MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis				Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %							
Plus 8 in..	16.4	9.2	37.5	53.3	0.7	11,940	2100	2200	2390	290	100	190
4 - 8 in..	16.2	9.3	37.1	53.6	0.6		2050	2180	2350	300	130	170
2 - 4 in..	15.0	9.1	37.1	53.8	0.7		2050	2160	2350	300	110	190
1½ - 2 in..	14.4	8.6	36.5	54.9	0.8		2040	2130	2300	260	90	170
1 - 1½ in..	14.7	9.8	36.1	54.1	0.9		2060	2200	2310	250	140	110
3/4 - 1 in..	14.0	9.7	36.6	53.7	0.9		2060	2190	2290	230	130	100
1/2 - 3/4 in..	15.4	11.0	36.5	52.5	0.9		2070	2180	2300	230	110	120
1/4 - 1/2 in..	12.5	11.4	35.6	53.0	0.8		2070	2170	2300	230	100	130
1/8 - 1/4 in..	11.6	12.9	35.8	51.3	0.8		2070	2170	2300	230	100	130
#48 - 1/8 in..	10.8	14.8	35.5	49.7	0.8		2070	2180	2300	230	110	120
0 - #48	6.4	20.8	34.3	44.9	0.7		2150	2250	2330	180	100	80
Mine Run....	15.5	10.1	36.0	53.9	0.7	11,870	2160	2260	2340	180	100	80
Plus 1½ in..	15.8	8.8	37.6	53.6	0.7	12,025	2070	2160	2350	280	90	190
0 - 1½ in..	15.2	11.5	37.0	51.5	0.9	11,500	2080	2180	2380	300	100	200
1/2 - 1½ in..	14.9	10.1	37.0	52.9	0.9	11,825*	2100	2220	2300	200	120	80
0 - 1/2 in..	13.9	12.7	36.6	50.7	0.8	11,200	2120	2230	2380	260	110	150

*Calculated

Classification of Coal by Rank

Specific Volatile Index	115-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 1 SEAM - STAR MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	57.9	4.0	0.6	1.2	12.2	8.6	15.5
Dry Basis	68.5	4.8	0.7	1.4	14.5	10.1	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	45.4	6.5	21.4	9.0	1.7	0.1	4.5	0.5	1.1	0.6	7.0	97.8

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index............................	-175
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index.........................	NON-CAKING

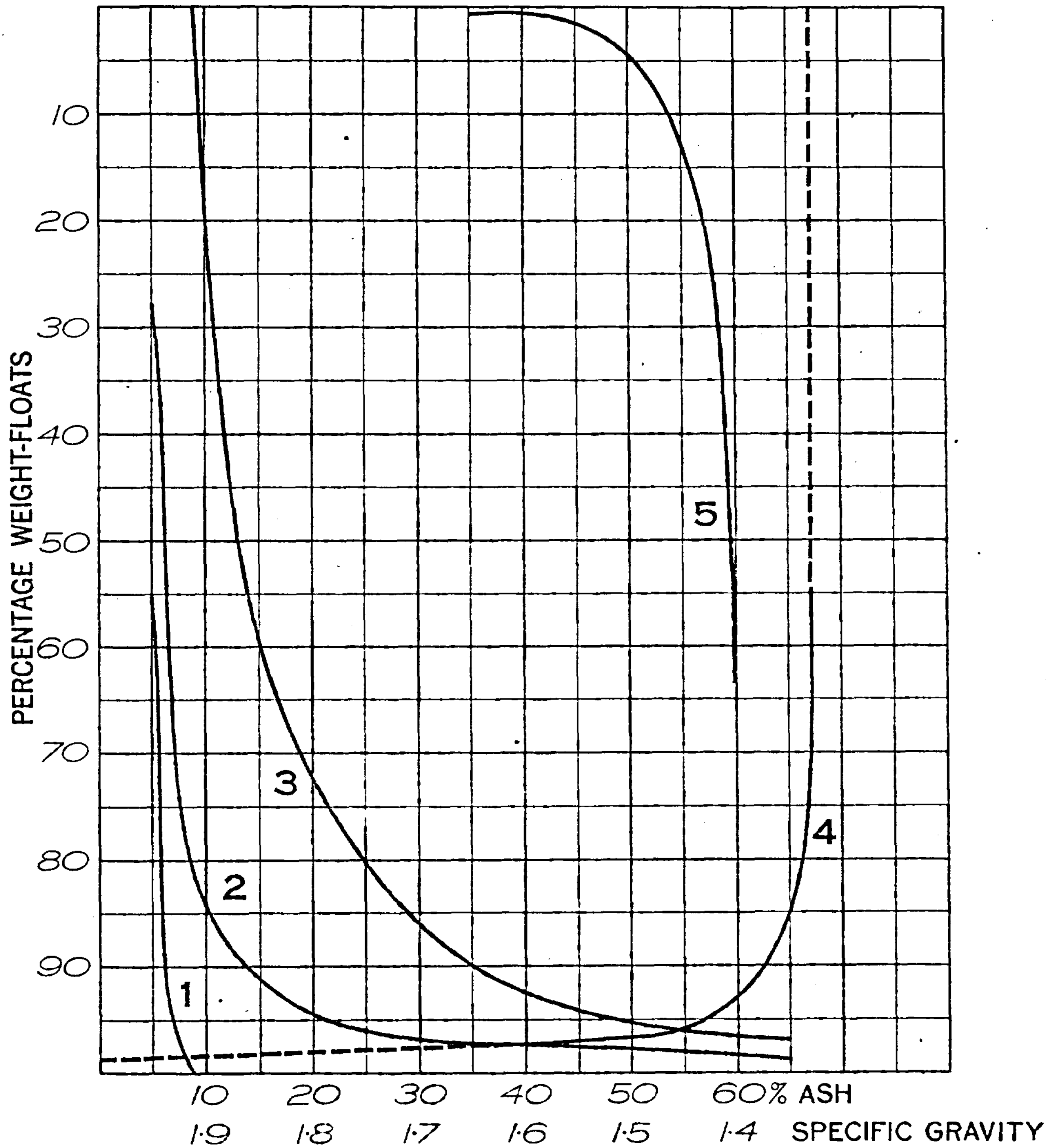

Figure 10 - Washability Curves for 1½ in. slack - No. 1 seam, Star Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 1 SEAM - STAR MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$ in. Slack

-Ash-

Specific Gravity				Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution: Gravity	±.10 Specific Gravity Distribution: Calculated Ordinate
		Floats	1.33	55.4	5.0	55.4	5.0	100.0	8.9	1.40	97.4
Sinks	1.33	"	1.40	37.0	8.6	92.4	6.4	44.6	13.8	1.45	13.1
"	1.40	"	1.50	3.6	19.2	96.0	6.9	7.6	38.9	1.55	1.5
"	1.50	"	1.60	1.0	31.6	97.0	7.2	4.0	56.6	1.65	1.0
"	1.60			3.0	64.9	100.0	8.9	3.0	64.9		
Curve No.				4	2	1, 2, 4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of $1\frac{1}{2}$" Slack (Dry Basis)

Specific Gravity				Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
		Floats	1.33	6.0	37.9	56.1	N.A.*	0.9	2050	2150	2300	250	100	150
Sinks	1.33	"	1.40	10.1	35.6	54.3	N.A.*	0.8	2140	2270	2310	170	130	40
"	1.40	"	1.50	21.8	35.2	43.0	N.A.*	0.7	2140	2240	2320	180	100	80
"	1.50	"	1.60	34.1	29.0	36.9	N.A.*	0.9	2170	2280	2370	200	110	90
"	1.60			70.6	19.9	10.5	N.A.*	1.5	2020	2120	2170	150	100	50

*Non-agglomerate

NO. 1 SEAM - STAR MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity				Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
		Floats	1.33	61.1	4.8	61.1	4.8	100.0	7.4
Sinks	1.33	"	1.40	34.2	9.5	95.3	6.5	38.9	11.4
"	1.40	"	1.50	4.1	18.0	99.4	7.0	4.7	25.6
"	1.50	"	1.60	0.0		99.4	7.0	0.6	77.6
"	1.60			0.6	77.6	100.0	7.4	0.6	77.6
Curve No.				4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity				Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
		Floats	1.33	49.3	5.7	49.3	5.7	100.0	7.2
Sinks	1.33	"	1.40	46.6	7.6	95.9	6.6	50.7	8.6
"	1.40	"	1.50	4.1	20.5	100.0	7.2	4.1	20.5
Curve No.				4	2	1,2,4	1	3	3

NO. 1 SEAM - STAR MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.45	Refuse Sinks 1.45
Weight.............................%	100.0	94.8	5.2
Proximate Analysis (dry basis)			
Ash...............................%	11.5	7.7	66.9
Volatile Matter...................%	37.0	36.9	19.0
Fixed carbon......................%	51.5	55.4	14.1
Sulphur...........................%	0.8	0.8	0.8
Calorific Value.......B.T.U./lb.	11,500	11,990	3,345
Fusion Point of Ash..........°F.	2180	2060	2470
Melting Range of Ash.........°F.	300	270	200
Coking Properties..............:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from $1\frac{1}{2}$ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.45

						Floats			Sinks		
Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Weight %	Ash %	F.P.A. °F.	Weight %	Ash %	F.P.A. °F.
1/2 - 1-1/2 inch	65.7	65.7	10.1	0.9	2220	96.1	7.8	2070	3.9	60.9	2080
0 - 1/2 inch	34.3	100.0	12.7	0.8	2230	90.5	7.6	2150	9.5	54.8	2270

ROSEDALE DISTRICT
NO. 5 SEAM
ROSEDALE MINE, ROSEDALE COLLIERIES LTD.
ROSEDALE, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	20.6	20.6	1.36	53.4	12.9
4 - 8 in..	33.6	54.2	1.35	51.8	10.2
2 - 4 in..	15.1	69.3	1.35	45.6	11.5
1½ - 2 in..	3.8	73.1	1.36	45.5	11.8
1 - 1½ in..	5.2	78.3	1.36	45.5	11.2
3/4 - 1 in..	3.2	81.5	1.35	43.6	11.0
1/2 - 3/4 in..	4.4	85.9	1.38	43.5	11.9
1/4 - 1/2 in..	6.2	92.1	1.39	42.5	13.4
1/8 - 1/4 in..	3.7	95.8	1.41	41.5	15.3
#48 - 1/8 in..	3.2	99.0	1.41 (#48 - 1/8 in. and 0 - #48 combined)	46.8 (#48 - 1/8 in. and 0 - #48 combined)	21.5
0 - #48	1.0	100.0			31.5
Mine Run		100.0		56.8	13.3
Plus 1½ in..		73.1			12.9
0 - 1½ in..		26.9		53.8	14.8
1/2 - 1½ in..		12.8		45.5	11.4
0 - 1/2 in..		14.1		51.0	17.0

	As Received
Average Size of Run-of-Mine.................in.	4.817

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	55.5	40.5
1½ - 2 in.		14.0	13.0
1 - 1½ in.		11.0	13.0
3/4 - 1 in.		5.5	7.0
1/2 - 3/4 in.		6.0	9.0
0 - 1/2 in.		8.0	17.5
Av'g Size in.	2.50	1.88	1.57
Size Stability.%		75.1	62.8

NO. 5 SEAM - ROSEDALE MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in.....	59.7			
8 - 10 in.....	40.3			
7 - 8 in.....			28.3	
6 - 7 in.....			25.0	
5 - 6 in.....			24.1	
4 - 5 in.....		1.1	22.6	1.0
3 - 4 in.....		10.6		7.6
2 - 3 in.....		29.1		33.1
$1\frac{1}{2}$ - 2 in.....		9.7		12.0
1 - $1\frac{1}{2}$ in.....		14.3		15.2
3/4 - 1 in.....		7.8		7.9
1/2 - 3/4 in.....		9.1		9.0
1/4 - 1/2 in.....		9.2		8.0
1/8 - 1/4 in.....		4.7		3.4
0 - 1/8 in.....		4.4		2.8
Av'g part.size in.	10.194	1.669	6.091	1.708
Size reduction...%		16.4		30.9

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	38.0
0 - 1-1/2 in..	38.6
0 - 1/2 in..	45.6

* See Appendix

NO. 5 SEAM - ROSEDALE MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis: Ash %	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Dry Basis: Sulphur %	Dry Basis: Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	16.8	12.9	34.6	52.5	0.5	11,275	2300	2400	2420	120	100	20
4 - 8 in..	16.7	10.2	36.2	53.6	0.6	11,665	2240	2400	2430	190	160	30
2 - 4 in..	15.7	11.5	34.9	53.6	0.5		2240	2340	2360	120	100	20
1½ - 2 in..	15.9	11.8	36.2	52.0	0.5		2240	2350	2360	120	110	10
1 - 1½ in..	15.8	11.2	35.1	53.7	0.5		2220	2310	2330	110	90	20
3/4 - 1 in..	15.8	11.0	35.9	53.1	0.6		2220	2300	2330	110	80	30
1/2 - 3/4 in..	16.9	11.9	34.2	53.9	0.5		2230	2320	2340	110	90	20
1/4 - 1/2 in..	17.4	13.4	34.1	52.5	0.6		2250	2420	2500	250	170	80
1/8 - 1/4 in..	16.8	15.3	33.7	51.0	0.5		2220	2310	2330	110	90	20
#48 - 1/8 in..	12.5	21.5	30.7	47.8	0.5		2200	2290	2370	170	90	80
0 - #48	5.5	31.5	28.2	40.3	0.5		2200	2260	2310	110	60	50
Mine Run....	16.4	13.3	34.6	52.1	0.5	11,175	2300	2400	2450	150	100	50
Plus 1½ in..	16.1	12.9	35.4	51.7	0.6	11,180	2300	2390	2440	140	90	50
0 - 1½ in..	18.4	14.8	33.4	51.8	0.5	10,955	2300	2395	2465	165	95	70
1/2 - 1½ in..	16.0	11.4	35.0	53.6	0.5	11,370*						
0 - 1/8 in..	15.6	23.8	31.2	45.0	0.5	9,675	2300	2410	2475	175	110	65

*Calculated.

Classification of Coal by Rank

Specific Volatile Index	109-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 5 SEAM - ROSEDALE MINE

TABLE VI. Ultimate Analyses
(Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	52.7	3.5	0.4	1.2	11.4	10.6	20.2
Dry Basis	66.1	4.3	0.5	1.5	14.3	13.3	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	48.3	1.9	26.0	7.8	1.1	0.02	7.0	0.7	0.6	0.4	6.7	99.92

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index..............................	-125
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray Caking Index...........................	NON-CAKING

NO. 5 SEAM - ROSEDALE MINE

TABLE IX. Float and Sink Data on 1/8 - 1½ in. Smalls
-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.32	5.6	3.5	5.6	3.5	100.0	12.0	1.40	96.2
Sinks 1.32 " 1.40	79.3	6.3	84.9	6.1	94.4	12.5	1.45	23.4
" 1.40 " 1.50	7.2	21.9	92.1	7.3	15.1	45.1	1.55	4.3
" 1.50 " 1.60	0.9	37.5	93.0	7.6	7.9	66.2	1.65	0.6
" 1.60	7.0	69.9	100.0	12.0	7.0	69.9	1.75	0.9
Curve No.	4	2	1, 2, 4	1	3	3	5	5

TABLE X. Float and Sink Data on 48 Mesh - 1/8 in. Fines
-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
Floats 1.35	15.1	4.7	15.1	4.7	100.0	18.3
Sinks 1.35 " 1.40	59.2	7.6	74.3	7.0	84.9	20.7
" 1.40 " 1.50	7.2	22.8	81.5	8.4	25.7	51.0
" 1.50 " 1.60	2.0	32.8	83.5	9.0	18.5	62.0
" 1.60	16.5	65.5	100.0	18.3	16.5	65.5
Curve No.	4	2	1, 2, 4	1	3	3

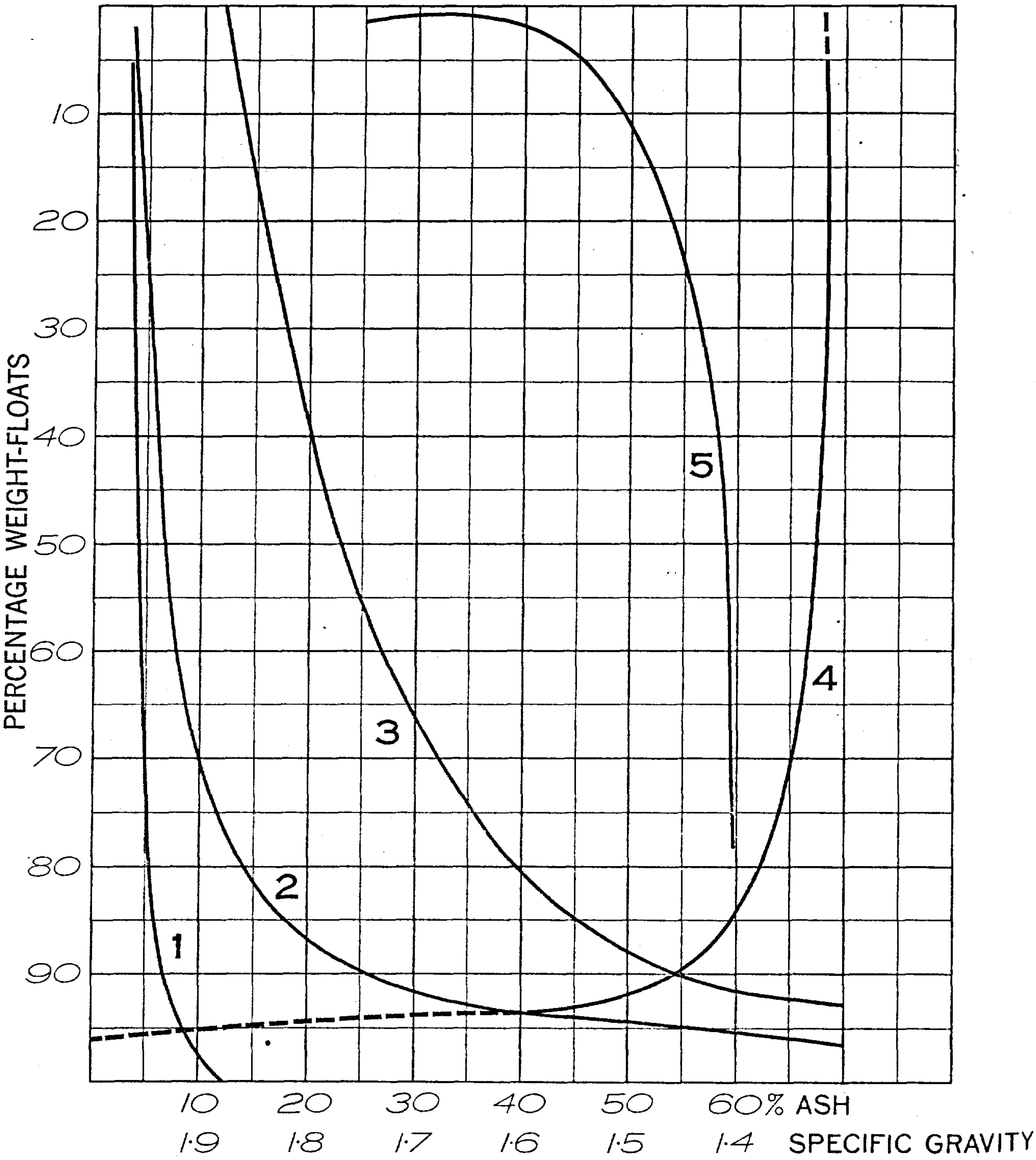

Figure 11 - Washability Curves for 1/8 x 1½ in. size - No.5 seam, Rosedale Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 5 SEAM - ROSEDALE MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity				Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
		Floats	1.32	13.0	3.6	13.0	3.6	100.0	8.3
Sinks	1.32	"	1.40	77.4	6.5	90.4	6.1	87.0	9.0
"	1.40	"	1.50	7.3	18.8	97.7	7.0	9.6	29.0
"	1.50	"	1.60	0.1	40.5	97.8	7.1	2.3	61.4
"	1.60			2.2	62.4	100.0	8.3	2.2	62.4
Curve No.				4	2	1,2,4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity				Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
		Floats	1.32	11.9	3.9	11.9	3.9	100.0	9.4
Sinks	1.32	"	1.40	69.1	6.5	81.0	6.1	88.1	10.2
"	1.40	"	1.50	17.6	21.0	98.6	8.8	19.0	23.6
"	1.50	"	1.60	0.5	32.4	99.1	8.9	1.4	56.4
"	1.60			0.9	69.8	100.0	9.4	0.9	69.8
Curve No.				4	2	1,2,4	1	3	3

NO. 5 SEAM - ROSEDALE MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

1/8 to 1-1/2 Inch Smalls

	Raw Coal	Clean Coal* Floats 1.45	Refuse* Sinks 1.45
Weight..........%	100.0	93.0	7.0
Proximate Analysis (dry basis)			
Ash..........%	12.6	9.0	76.0
Volatile Matter..........%	34.5	35.9	9.5
Fixed carbon..........%	52.9	55.1	14.5
Sulphur..........%	0.5	0.5	0.1
Calorific Value.......B.T.U./lb.	11,265	11,730	3,095
Fusion Point of Ash..........°F.	2310	2310	2630
Melting Range of Ash..........°F.	110	110	250
Coking Properties..........:	N.A.**	N.A.**	N.A.**

TABLE XIV. Chemical Analyses of Raw Coal, Clean Coal and Refuse

1-1/2 to 4 Inch Lump

	Raw Coal	Clean Coal* Floats 1.45	Refuse* Sinks 1.45
Weight..........%	100.0	97.8	2.2
Proximate Analysis (dry basis)			
Ash..........%	11.6	8.4	68.0
Volatile Matter..........%	35.2	36.5	12.7
Fixed carbon..........%	53.2	55.1	19.3
Sulphur..........%	0.5	0.5	0.1
Calorific Value......B.T.U./lb.	11,485	11,900	4,155
Fusion Point of Ash..........°F.	2340	2300	
Melting Range of Ash..........°F.	120	110	
Coking Properties..........:	N.A.**	N.A.**	N.A.**

*Calculated

**Non-agglomerate

ROSEDALE DISTRICT
NO. 2 SEAM
ARCADIA NO. 2 MINE, ARCADIA COAL MINES LTD.
WILLOW CREEK, ALBERTA
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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs.per cu. ft.	Ash %
Plus 8 in..	20.7	20.7	1.34	51.4	6.6
4 - 8 in..	39.8	60.5	1.34	51.0	7.3
2 - 4 in..	16.9	77.4	1.35	44.4	7.4
1½ - 2 in..	3.2	80.6	1.35	43.0	10.5
1 - 1½ in..	4.1	84.7	1.35	42.3	11.3
3/4 - 1 in..	2.0	86.7	1.34	42.6	
1/2 - 3/4 in..	2.6	89.3	1.34	41.4	
1/4 - 1/2 in..	4.0	93.3	1.34	41.1	10.4
1/8 - 1/4 in..	3.0	96.3	1.35	41.0	9.6
#48 - 1/8 in..	2.9	99.2	1.35 (#48 - 1/8 in. and 0 - #48 combined)	45.7 (#48 - 1/8 in. and 0 - #48 combined)	10.4
0 - #48	0.8	100.0			16.6
Mine Run		100.0		54.9	8.6
Plus 1½ in..		80.6			7.3
0 - 1½ in..		19.4		53.0	10.5
1/2 - 1½ in..		8.7		44.3	9.8
0 - 1/2 in..		10.7		48.0	11.3

	As Received
Average Size of Run-of-Mine..................in.	5.072

*All Screen 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Tests, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	59.5	43.5
1½ - 2 in.		15.5	18.5
1 - 1½ in.		10.0	14.0
3/4 - 1 in.		4.0	5.0
1/2 - 3/4 in.		3.5	5.0
0 - 1/2 in.		7.5	14.0
Av'g Size in.	2.50	1.96	1.70
Size Stability.%		78.4	68.0

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in.....	27.1			
8 - 10 in.....	72.9			
7 - 8 in.....			27.4	
6 - 7 in.....			24.9	
5 - 6 in.....			25.6	
4 - 5 in.....		0.2	22.1	0.3
3 - 4 in.....		2.3		2.6
2 - 3 in.....		32.1		33.9
$1\frac{1}{2}$ - 2 in.....		18.5		19.9
1 - $1\frac{1}{2}$ in.....		12.4		12.3
3/4 - 1 in.....		7.6		6.2
1/2 - 3/4 in.....		7.2		6.5
1/4 - 1/2 in.....		8.4		8.1
1/8 - 1/4 in.....		5.3		5.1
0 - 1/8 in.....		6.0		5.1
Av'g part.size in.	9.542	1.530	6.077	1.593
Size reduction...%		16.0		26.2

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run.......	36.6
0 - 1-1/2 in..	35.2
0 - 1/2 in..	34.5

*See Appendix

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis Ash %	Dry Basis Volatile Matter %	Dry Basis Fixed Carbon %	Dry Basis Sulphur %	Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	15.0	6.6	36.6	56.8	0.7	12,175	1900	1970	2090	190	70	120
4 - 8 in..	13.3	7.3	37.7	55.0	0.7		2010	2080	2160	150	70	80
2 - 4 in..	11.8	7.4	37.8	54.8	0.7		2010	2080	2170	160	70	90
1½ - 2 in..	9.2	10.5	36.1	53.4	0.7		1950	2020	2230	280	70	210
1 - 1½ in..	9.1	11.3	34.7	54.0	0.7		2020	2090	2250	230	70	160
3/4 - 1 in..	9.2				0.7		(1)					
1/2 - 3/4 in..	9.4				0.6		(1)2060	2160	2280	220	100	120
1/4 - 1/2 in..	13.6	10.4	35.6	54.0	0.7		2010	2080	2190	180	70	110
1/8 - 1/4 in..	14.5	9.6	36.4	54.0	0.7		2000	2060	2170	170	60	110
#48 - 1/8 in..	10.6	10.4	35.5	54.1	0.7		2050	2110	2170	120	60	60
0 - #48	4.1	16.6	34.1	49.3	0.8		2100	2160	2370	270	60	210
Mine Run....	14.4	8.6	36.0	55.4	0.7	11,860	1950	2030	2140	190	80	110
Plus 1½ in..	13.1	7.3	37.0	55.7	0.7	12,100	1920	2000	2100	180	80	100
0 - 1½ in..	15.4	10.5	36.9	52.6	0.7	11,605	1970	2050	2180	210	80	130
1/2 - 1½ in..	13.2	9.8	35.5	54.7	0.7	11,795	1930	2060	2190	260	130	130
0 - 1/2 in..	15.0	11.3	35.9	52.8	0.7	11,380	2050	2120	2250	200	70	130

(1) Proximate Analysis omitted because of unavoidable contamination.

Classification of Coal by Rank

Specific Volatile Index	110-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon	Hydrogen	Sulphur	Nitrogen	Oxygen	Ash	Moisture
	%	%	%	%	%	%	%
As Received	59.0	3.7	0.6	1.4	13.5	7.4	14.4
Dry Basis	68.9	4.4	0.7	1.6	15.8	8.6	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	Na_2O	K_2O	P_2O_5	TiO_2	SO_3	Total
	%	%	%	%	%	%	%	%	%	%	%	%
Mine Run	47.6	5.0	16.8	10.3	1.8	0.02	5.6	0.7	0.8	0.4	9.9	98.92

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index..............................	-165
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index..........................	NON-CAKING

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$ in. Slack
-Ash-

Specific Gravity	Weight	Ash	Cumulative Floats Weight	Cumulative Floats Ash	Cumulative Sinks Weight	Cumulative Sinks Ash	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
	%	%	%	%	%	%		
Floats 1.34	65.9	5.0	65.9	5.0	100.0	9.4	1.35	97.5
Sinks 1.34 " 1.40	28.1	6.8	94.0	5.5	34.1	17.8	1.40	29.7
" 1.40 " 1.50	0.9	27.7	94.9	5.7	6.0	63.9	1.45	7.1
" 1.50 " 1.60	0.6	41.3	95.5	6.0	5.1	76.6	1.55	0.7
" 1.60	4.5	81.3	100.0	9.4	4.5	81.3	1.65	0.1
Curve No.	4	2	1, 2, 4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of $1\frac{1}{2}$" Slack
(Dry Basis)

Specific Gravity	Ash	Volatile Matter	Fixed Carbon	Coking Properties	Sulphur	Initial Deformation	Softening Point	Fluid Temperature	Melting Range	Softening Interval	Flow Interval
	%	%	%		%	°F.	°F.	°F.	°F.	°F.	°F.
Floats 1.34	5.5	36.7	57.8	N.A.*	0.7	1870	1950	1970	100	80	20
Sinks 1.34 " 1.40	7.6	37.6	54.8	N.A.*	0.7	1880	1960	2100	220	80	140
" 1.40 " 1.50	29.5	31.5	39.0	N.A.*	0.6	2150	2270	2300	150	120	30
" 1.50 " 1.60	43.9	24.8	31.3	N.A.*	0.4	2180	2300	2320	140	120	20
" 1.60	85.0	10.6	4.4	N.A.*	0.4	2130	2310	2700+	570+	180	390+

*Non-agglomerate

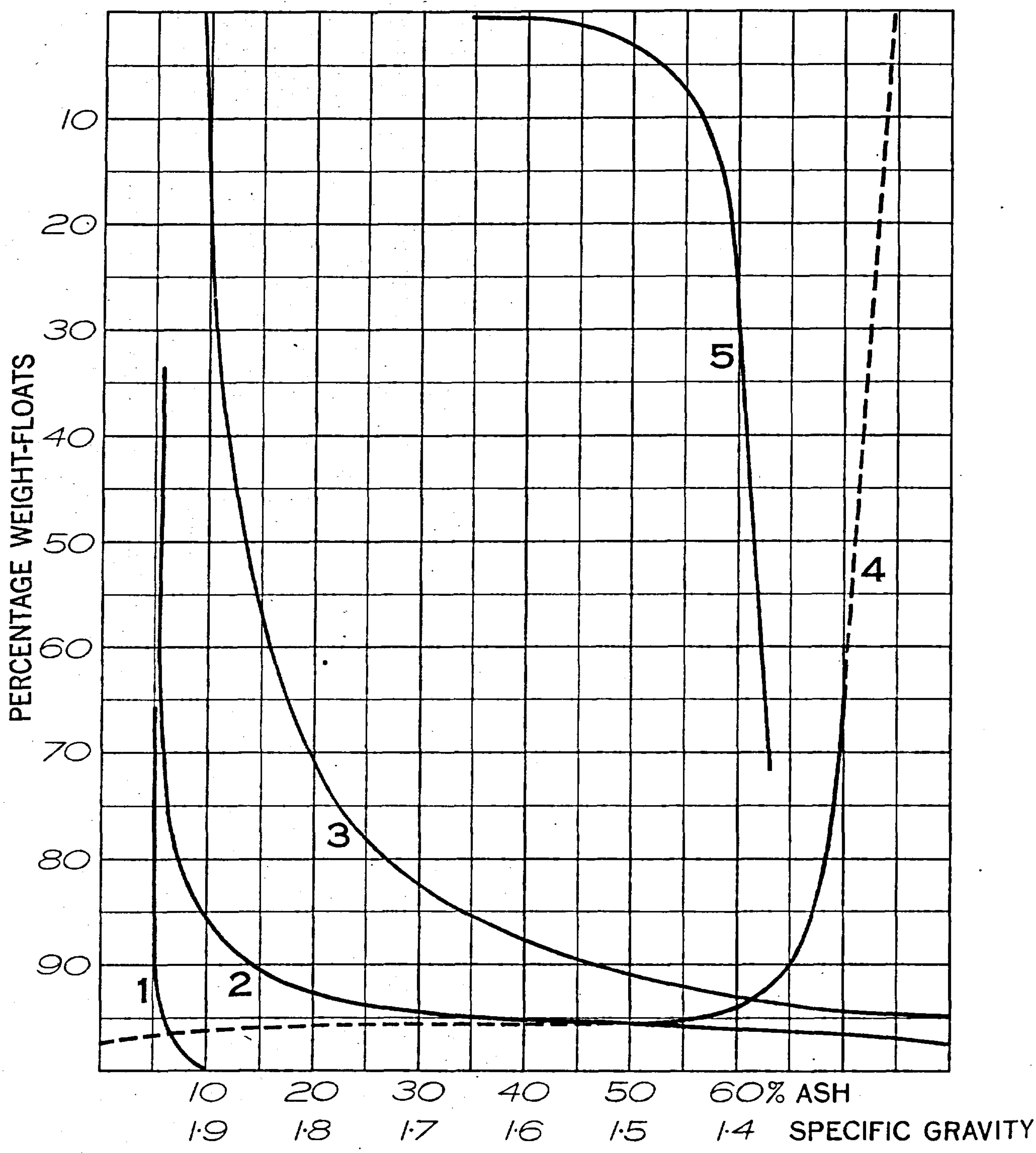

Figure 12 - Washability Curves for 1½ in. slack - No.2 seam, Arcadia Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific Gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
Floats 1.34	77.2	5.5	77.2	5.5	100.0	7.1
Sinks 1.34 " 1.40	21.9	9.7	99.1	6.4	22.8	12.5
" 1.40 " 1.50	0.0		99.1	6.4	0.9	81.8
" 1.50 " 1.60	0.0		99.1	6.4	0.9	81.8
" 1.60	0.9	81.8	100.0	7.1	0.9	81.8
Curve No. 4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
Floats 1.34	61.9	5.5	61.9	5.5	100.0	6.3
Sinks 1.34 " 1.40	37.9	7.6	99.8	6.3	38.1	7.7
" 1.40 " 1.50	0.1	18.3	99.9	6.3	0.2	29.0
" 1.50 " 1.60	0.1	39.6	100.0	6.3	0.0	39.6
" 1.60	0.0		100.0		0.0	
Curve No. 4		2	1, 2, 4	1	3	3

NO. 2 SEAM - ARCADIA NO. 2 MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.45	Refuse Sinks 1.45
Weight.............................%	100.0	92.5	7.2
Proximate Analysis (dry basis)			
Ash................................%	10.5	6.5	75.8
Volatile Matter....................%	36.9	37.1	12.7
Fixed carbon.......................%	52.6	56.4	11.5
Sulphur............................%	0.7	0.7	0.4
Calorific Value.......B.T.U./lb.	11,605	12,015	2,840
Fusion Point of Ash..........°F.	2050	1960	2320
Melting Range of Ash.........°F.	210	100	510+
Coking Properties..............:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.45

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	44.9	44.9	9.8	0.7	1060	92.4	7.2	2020	7.6	88.3	2360
0 - 1/2 inch	55.1	100.0	11.3	0.7	2120	92.5	6.2	2030	7.5	77.1	2320

EAST COULEE DISTRICT
NO. 2 SEAM
MURRAY MINE, MURRAY COLLIERIES LTD.
EAST COULEE, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	19.3	19.3	1.38	51.7	8.5
4 - 8 in..	33.3	52.6	1.39	50.7	8.7
2 - 4 in..	22.2	74.8	1.39	46.1	8.8
1½ - 2 in..	5.3	80.1	1.40	45.0	10.9
1 - 1½ in..	6.2	86.3	1.40	44.3	10.8
3/4 - 1 in..	2.8	89.1	1.38	40.6	10.7
1/2 - 3/4 in..	3.3	92.4	1.40	43.9	12.7
1/4 - 1/2 in..	3.5	95.9	1.39	42.0	11.1
1/8 - 1/4 in..	1.9	97.8	1.40	43.3	10.6
#48 - 1/8 in..	1.8	99.6	1.41 (#48 - 1/8 in. and 0 - #48)	48.0	12.6
0 - #48	0.4	100.0			18.7
Mine Run		100.0		57.1	9.1
Plus 1½ in..		80.1			8.8
0 - 1½ in..		19.9		51.8	10.9
1/2 - 1½ in..		12.3			11.0
0 - 1/2 in..		7.6			11.5

	As Received
Average Size of Run-of-mine..................in.	4.645

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in..	100.0	50.5	32.5
1½ - 2 in..		15.0	19.5
1 - 1½ in..		13.5	16.0
3/4 - 1 in..		7.0	8.0
1/2 - 3/4 in..		5.5	9.0
0 - 1/2 in..		8.5	15.0
Av'g Size in..	2.50	1.81	1.52
Size Stability.%		72.4	60.8

NO. 2 SEAM - MURRAY MINE

TABLE III. Crushing Tests
(Crusher set at 1½ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in.....	21.8			
8 - 10 in.....	78.2			
7 - 8 in.....			16.8	
6 - 7 in.....			30.6	
5 - 6 in.....			17.7	
4 - 5 in.....			34.9	
3 - 4 in.....		4.4		2.5
2 - 3 in.....		32.3		36.4
1½ - 2 in.....		16.2		19.0
1 - 1½ in.....		11.8		12.4
3/4 - 1 in.....		7.3		7.4
1/2 - 3/4 in.....		7.3		6.6
1/4 - 1/2 in.....		8.7		7.2
1/8 - 1/4 in.....		5.6		4.3
0 - 1/8 in.....		6.4		4.2
Av'g part.size in.	9.436	1.551	5.794	1.630
Size reduction...%		16.4		28.1

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove Index*	
Mine Run......	35.9**	35.9#
0 - 1-1/2 in..	37.3**	35.9##
0 - 1/2 in..	36.6**	

* See Appendix
** Standard test - containing 6.5% moisture
\# Tested as received with 17.2% moisture
\## Tested as received with 17.6% moisture

NO. 2 SEAM - MURRAY MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	18.5	8.5	38.5	53.0	0.8		1920	2020	2100	180	100	80
4 - 8 in..	18.0	8.7	37.1	54.2	0.6	11,840	1920	2000	2080	160	80	80
2 - 4 in..	17.4	8.8	39.0	52.2	0.6		1960	2060	2140	180	100	80
1½ - 2 in..	16.9	10.9	38.1	51.0	0.7		1950	2050	2140	190	100	90
1 - 1½ in..	16.8	10.8	35.9	53.3	0.7		1940	2040	2100	160	100	60
3/4 - 1 in..	14.4	10.7	36.8	52.5	0.8		2040	2140	2250	210	100	110
1/2 - 3/4 in..	13.5	12.7	36.2	51.1	1.3		2040	2150	2300	260	110	150
1/4 - 1/2 in..	13.7	11.1	37.0	51.9	0.8		2040	2150	2250	210	110	100
1/8 - 1/4 in..	15.6	10.6	36.9	52.5	0.8		1950	2050	2140	190	100	90
#48 - 1/8 in..	15.0	12.6	35.8	51.6	0.8		1960	2060	2150	190	100	90
0 - #48	6.5	18.7	34.5	46.8	0.8		2060	2200	2350	290	140	150
Mine Run....	18.0	9.1	36.7	54.2	0.7	11,785	1910	2020	2220	310	110	200
Plus 1½ in..	18.1	8.8	39.5	51.7	0.8	11,750	1910	2000	2200	290	90	200
0 - 1½ in..	17.8	10.9	37.3	51.8	0.7	11,495	1900	2000	2200	300	100	200
1/2 - 1½ in..	16.5	11.0	39.2	49.8	0.7	11,440	1900	2000	2200	300	100	200
0 - 1/2 in..	15.9	11.5	38.6	49.9	0.7	11,320	1930	2030	2200	270	100	170

Classification of Coal by Rank

Specific Volatile Index 110-Black Lignite
A.S.T.M. Classification Subbituminous B

NO. 2 SEAM - MURRAY MINE

TABLE VI. Ultimate Analyses
(Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	55.0	3.6	0.6	1.1	12.7	7.3	19.7
Dry Basis	68.5	4.4	0.7	1.3	16.0	9.1	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	33.8	10.2	23.4	11.3	1.9	0.5	6.0	1.0	0.7	0.5	8.3	97.6

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index..........................	110
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray Caking Index.......................	NON-CAKING

NO. 2 SEAM - MURRAY MINE

TABLE IX. Float and Sink Data on 1½ in. Slack
-Ash-

Specific Gravity	Weight	Ash	Cumulative				±.10 Specific Gravity Distribution	
			Floats		Sinks			
			Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
	%	%	%	%	%	%		
Floats 1.33	29.8	5.6	29.8	5.6	100.0	10.0	1.40	96.8
Sinks 1.33 " 1.40	54.6	7.2	84.4	6.6	70.2	11.9	1.45	49.5
" 1.40 " 1.50	10.0	14.7	94.4	7.5	15.6	28.2	1.55	5.5
" 1.50 " 1.60	1.6	24.7	96.0	7.8	5.6	52.4	1.65	1.3
" 1.60	4.0	63.5	100.0	10.0	4.0	63.5	1.75	0.6
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of 1½" Slack
(Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	6.4	38.2	55.9	N.A.*	0.9	1970	2100	2200	230	130	100
Sinks 1.33 " 1.40	8.3	37.9	53.8	N.A.*	0.6	2040	2140	2210	170	100	70
" 1.40 " 1.50	16.5	35.5	48.0	N.A.*	1.4	2090	2140	2420	330	50	280
" 1.50 " 1.60	26.9	30.6	42.5	N.A.*	2.0	2000	2140	2360	360	140	220
" 1.60	67.0	21.1	11.9	N.A.*	0.6	2090	2140	2400	310	50	260

*Non-agglomerate

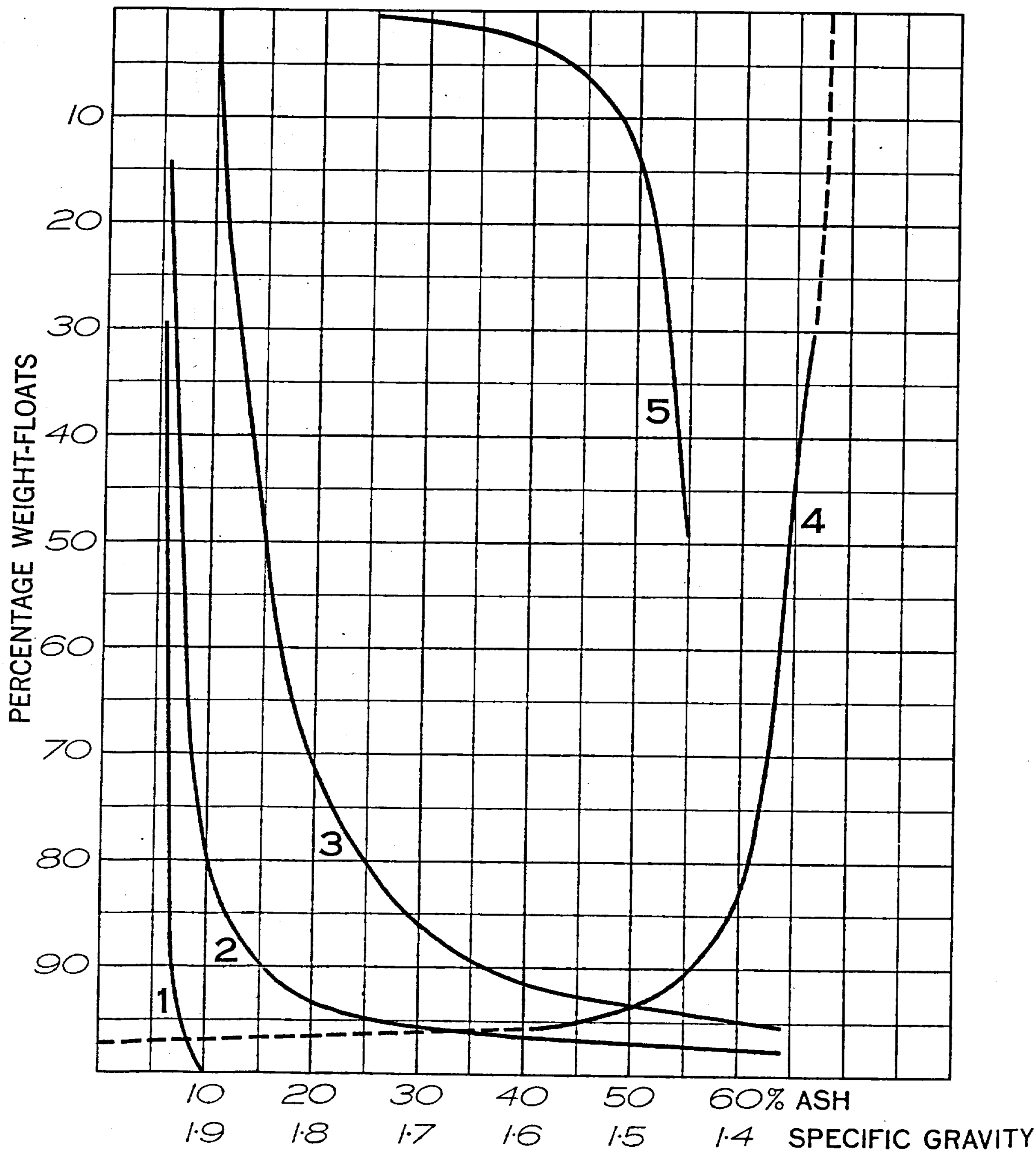

Figure 13 - Washability Curves for 1½ in. slack - No.2 seam, Murray Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 2 SEAM - MURRAY MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity		Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats 1.33	42.1	5.6	42.1	5.6	100.0	7.3
Sinks 1.33	" 1.40	50.4	8.0	92.5	6.9	57.9	8.6
" 1.40	" 1.50	7.5	12.8	100.0	7.3	7.5	12.8
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %
	Floats 1.33	25.2	5.7	25.2	5.7	100.0	7.0
Sinks 1.33	" 1.40	68.2	6.6	93.4	6.4	74.8	7.4
" 1.40	" 1.50	6.6	15.9	100.0	7.0	6.6	15.9
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight.............................%	100.0	94.4	5.6
Proximate Analysis (dry basis)			
Ash...........................%	10.9	8.1	59.3
Volatile matter...............%	37.3	35.5	22.7
Fixed carbon..................%	51.8	56.4	18.0
Sulphur.......................%	0.7	0.7	1.9
Calorific Value.......B.T.U./lb.	11,495	11,990	4,395
Fusion Point of Ash..........°F.	2000	2000	2110
Melting Range of Ash.........°F.	300	160	200
Caking Properties..............:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from $1\frac{1}{2}$ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	61.8	61.8	11.0	0.7	2000	92.4	8.8	2000	7.6	65.8	2130
0 - 1/2 inch	38.2	100.0	11.5	0.7	2030	90.9	8.3	1980	9.1	57.4	2120

EAST COULEE DISTRICT
NO. 2 (EAST COULEE) SEAM
WESTERN CROWN MINE, MONARCH COAL MINING CO., LTD.
EAST COULEE, ALBERTA

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TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	10.0	10.0	1.35	49.6	8.6
4 - 8 in..	34.7	44.7	1.36	50.0	9.9
2 - 4 in..	25.1	69.8	1.36	45.0	10.8
1½ - 2 in..	5.8	75.6	1.37	43.9	12.8
1 - 1½ in..	7.0	82.6	1.38	44.3	12.2
3/4 - 1 in..	3.6	86.2	1.38	44.5	12.6
1/2 - 3/4 in..	3.9	90.1	1.38	42.6	12.5
1/4 - 1/2 in..	4.4	94.5	1.38	43.0	12.0
1/8 - 1/4 in..	2.5	97.0	1.38	41.8	13.2
#48 - 1/8 in..	2.2	99.2	1.40	47.1	15.7
0 - #48	0.8	100.0			21.1
Mine Run		100.0		58.2	11.1
Plus 1½ in..		75.6			10.1
0 - 1½ in..		24.4		51.3	13.2
1/2 - 1½ in..		14.5		45.8	11.9
0 - 1/2 in..		9.9		48.4	14.1

	As Received
Average Size of Run-of-Mine................in.	4.016

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	55.0	33.5
1½ - 2 in.		13.0	20.5
1 - 1½ in.		16.5	18.0
3/4 - 1 in.		3.5	7.5
1/2 - 3/4 in.		5.0	7.0
0 - 1/2		7.0	13.5
Av'g Size in.	2.50	1.89	1.56
Size Stability.%		75.6	62.4

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE III. Crushing Tests
(Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
10 - 12 in.....	42.0			
8 - 10 in.....	58.0			
7 - 8 in.....			18.4	
6 - 7 in.....			21.3	
5 - 6 in.....			32.0	
4 - 5 in.....			28.3	
3 - 4 in.....		3.4		2.8
2 - 3 in.....		28.1		31.0
$1\frac{1}{2}$ - 2 in.....		16.6		18.3
1 - $1\frac{1}{2}$ in.....		13.8		15.8
3/4 - 1 in.....		9.3		8.9
1/2 - 3/4 in.....		8.8		7.7
1/4 - 1/2 in.....		9.6		7.8
1/8 - 1/4 in.....		5.0		3.8
0 - 1/8 in.....		5.4		3.9
Av'g part. size in.	9.840	1.470	5.798	1.556
Size reduction...%		14.9		26.8

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	35.5
0 - 1-1/2 in..	35.5
0 - 1/2 in..	35.2

*See Appendix

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.	Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Plus 8 in..	15.8	8.6	38.2	53.2	0.9	11,875	1980	2070	2140	160	90	70
4 - 8 in..	15.1	9.9	38.5	51.6	1.0		1990	2080	2150	160	90	70
2 - 4 in..	14.1	10.8	37.1	52.1	1.2		2000	2100	2160	160	100	60
1½ - 2 in..	13.4	12.8	36.0	51.2	1.1		2010	2120	2200	190	110	80
1 - 1½ in..	15.2	11.2	37.4	51.4	1.0		2010	2100	2160	150	90	60
3/4 - 1 in..	15.4	12.6	36.4	51.0	1.2		1950	2050	2220	270	100	170
1/2 - 3/4 in..	16.0	12.5	36.4	51.1	1.3		2010	2130	2230	220	120	100
1/4 - 1/2 in..	14.5	12.0	35.6	52.4	1.2		2000	2100	2210	210	100	110
1/8 - 1/4 in..	16.1	13.2	34.9	51.9	1.2		2030	2150	2260	230	120	110
#48 - 1/8 in..	11.4	15.7	34.5	49.8	1.4		2040	2160	2260	220	120	100
0 - #48	5.6	21.1	33.4	45.5	1.2		2020	2140	2250	230	120	110
Mine Run....	15.6	11.1	36.1	52.8	1.0	11,570	1980	2100	2170	190	120	70
Plus 1½ in..	15.5	10.1	36.5	53.4	0.8	11,670	1980	2100	2170	190	120	70
0 - 1½ in..	15.0	13.2	36.9	49.9	1.1	11,220	1970	2060	2250	280	90	190
1/2 - 1½ in..	15.6	11.9	36.9	51.2	1.2	11,375*	2060	2140	2220	160	80	80
0 - 1/2 in..	16.6	14.1	35.8	50.1	1.5	11,100	2000	2110	2190	190	110	80

*Calculated

Classification of Coal by Rank

Specific Volatile Index	104-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
Dry Basis	67.2	4.6	1.0	1.3	14.8	11.1	
As received	56.7	3.9	0.9	1.1	12.4	9.4	15.6

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	47.2	10.1	17.0	7.4	1.4	0.2	4.5	1.2	0.5	0.4	7.1	97.0

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index..........................	-165
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray caking index........................	NON-CAKING

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$ in. Slack

-Ash-

Specific Gravity	Weight %	Ash %	Cumulative Floats Weight %	Cumulative Floats Ash %	Cumulative Sinks Weight %	Cumulative Sinks Ash %	±.10 Specific Gravity Distribution Gravity	±.10 Specific Gravity Distribution Calculated Ordinate
Floats 1.33	44.3	4.8	44.3	4.8	100.0	11.8	1.40	94.0
Sinks 1.33 " 1.40	39.3	8.5	83.6	6.5	55.7	17.3	1.45	21.9
" 1.40 " 1.50	6.7	18.7	90.3	7.4	16.4	38.4	1.55	7.6
" 1.50 " 1.60	3.6	29.8	93.9	8.3	9.7	52.1	1.65	2.6
" 1.60	6.1	65.2	100.0	11.8	6.1	65.2	1.75	1.2
Curve No.	4	2	1,2,4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of $1\frac{1}{2}$" Slack (Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	5.6	39.4	55.0	N.A.*	0.8	1940	2070	2140	200	130	70
Sinks 1.33 " 1.40	9.8	36.9	53.3	N.A.*	0.9	1960	2060	2150	190	100	90
" 1.40 " 1.50	20.7	35.3	44.0	N.A.*	1.5	2040	2160	2240	200	120	80
" 1.50 " 1.60	32.1	31.0	36.9	N.A.*	1.6	2060	2130	2210	150	70	80
" 1.60	69.8	16.6	13.6	N.A.*	3.9	2130	2200	2270	140	70	70

*Non-agglomerate

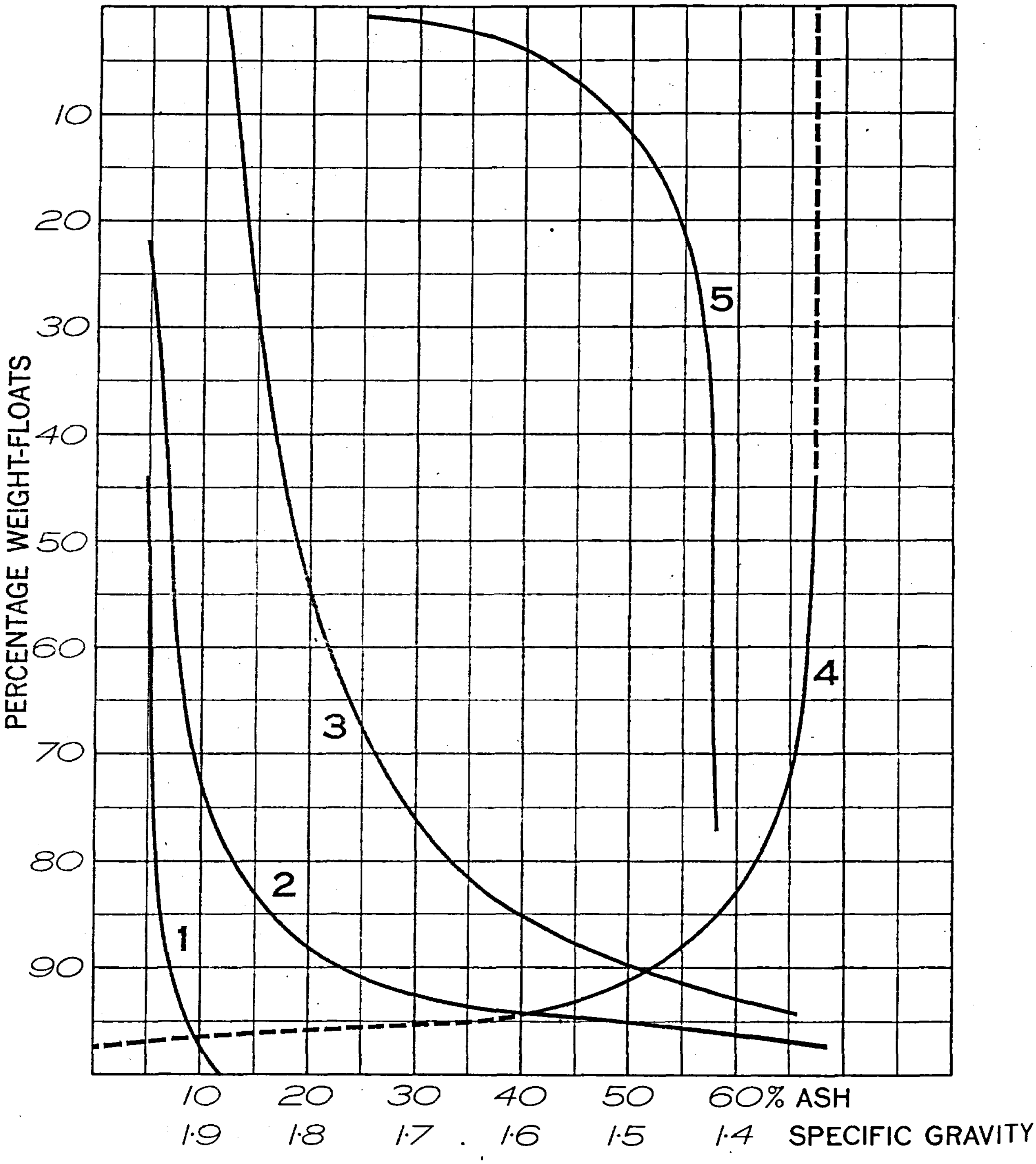

Figure 14 - Washability Curves for 1½ in. slack - No.3 seam, Western Crown Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE XI. Float and Sink Data on 1½-4 in. Lump

-Ash-

Specific Gravity		Weight	Ash	Cumulative			
				Floats		Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	50.1	5.9	50.1	5.9	100.0	10.2
Sinks 1.33	" 1.40	36.6	9.3	86.7	7.3	49.9	14.5
" 1.40	" 1.50	10.1	20.5	96.8	8.7	13.3	28.7
" 1.50	" 1.60	0.8	35.1	97.6	8.9	3.2	54.5
" 1.60		2.4	61.0	100.0	10.2	2.4	61.0
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight	Ash	Cumulative			
				Floats		Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.33	57.9	5.5	57.9	5.5	100.0	8.2
Sinks 1.33	" 1.40	32.8	8.9	90.7	6.7	42.1	12.0
" 1.40	" 1.50	8.8	22.2	99.5	8.1	9.3	23.0
" 1.50	" 1.60	0.3	32.3	99.8	8.2	0.5	37.1
" 1.60		0.2	44.2	100.0	8.2	0.2	44.2
Curve No.	4		2	1, 2, 4	1	3	3

NO. 2 (EAST COULEE) SEAM - WESTERN CROWN MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.55	Refuse Sinks 1.55
Weight...............................%	100.0	93.2	6.8
Proximate Analysis (dry basis)			
Ash...............................%	13.2	9.2	55.8
Volatile Matter...................%	36.9	36.0	22.4
Fixed carbon......................%	49.9	54.8	21.8
Sulphur...........................%	1.1	0.9	4.1
Calorific Value.......B.T.U./lb.	11,220	11,590	5,065
Fusion Point of Ash..........°F.	2060	2070	2150
Melting Range of Ash.........°F.	280	130	200
Coking Properties...............:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.55

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	59.4	59.4	11.9	1.2	2140	92.2	9.2	2080	7.8	63.2	2300
0 - 1/2 inch	40.6	100.0	14.1	1.5	2110	89.5	8.3	2040	10.5	60.8	2160

EAST COULEE DISTRICT
NO. 2 (EAST COULEE) SEAM
ATLAS MINE, REGAL COAL CO., LTD.
EAST COULEE, ALBERTA
----------0---------

TABLE I. Screen Analysis, Specific Gravity, and Bulk Density

Screen Sizes*	As Received % by weight	As Received % Cumulative	Specific Gravity	Bulk Density lbs. per cu. ft.	Ash %
Plus 8 in..	30.2	30.2	1.35	51.0	9.2
4 - 8 in..	23.1	53.3	1.36	50.3	9.5
2 - 4 in..	15.0	68.3	1.37	44.0	8.8
1½ - 2 in..	5.5	73.8	1.37	44.6	10.0
1 - 1½ in..	7.5	81.3	1.38	43.5	10.1
3/4 - 1 in..	3.7	85.0	1.37	42.6	10.3
1/2 - 3/4 in..	4.3	89.3	1.39	39.3	10.7
1/4 - 1/2 in..	4.9	94.2	1.37	41.8	10.7
1/8 - 1/4 in..	2.7	96.9	1.38	40.0	10.8
#48 - 1/8 in..	2.3	99.2	1.39 (#48 - 1/8 in. and 0 - #48 combined)	44.0 (#48 - 1/8 in. and 0 - #48 combined)	12.0
0 - #48	0.8	100.0			16.6
Mine Run		100.0		55.8	9.9
Plus 1½ in..		73.8			9.7
0 - 1½ in..		26.2		49.0	10.8
1/2 - 1½ in..		15.5		43.8	10.6
0 - 1/2 in..		10.7		47.3	12.1

	As Received
Average Size of Run-of-mine.................in.	5.551

*All screens 1/8 in. and larger are round-hole screens. No. 48 is Tyler 48-mesh with nominal aperture of 0.295 mm.

TABLE II. Size Stability

Screen Sizes	Screen Analysis Before and After Drop-Shatter Test, 2 - 3 inch: Before Test %	After 2 Drops %	After 4 Drops %
2 - 3 in.	100.0	52.5	35.2
1½ - 2 in.		13.9	17.8
1 - 1½ in.		14.9	17.8
3/4 - 1 in.		5.4	7.4
1/2 - 3/4 in.		5.4	6.9
0 - 1/2 in.		7.9	14.9
Av'g Size in.	2.50	1.843	1.559
Size Stability.%		73.7	62.4

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE III. Crushing Tests (Crusher set at $1\frac{1}{2}$ inch)

Size Crushed	Plus 8 inch Lump		4-8 inch Lump	
	Screen Analysis		Screen Analysis	
Screen Sizes	Before Crushing %	After Crushing %	Before Crushing %	After Crushing %
14 - 16 in....	11.9			
12 - 14 in....	31.1			
10 - 12 in....	27.5			
8 - 10 in....	29.5			
7 - 8 in....			27.7	
6 - 7 in....			16.0	
5 - 6 in....			27.7	
4 - 5 in....			28.6	
3 - 4 in....		4.0		3.3
2 - 3 in....		33.9		30.5
$1\frac{1}{2}$ - 2 in....		17.0		22.4
1 - $1\frac{1}{2}$ in....		12.8		15.0
3/4 - 1 in....		7.9		8.4
1/2 - 3/4 in....		7.2		6.9
1/4 - 1/2 in....		7.9		6.8
1/8 - 1/4 in....		4.1		3.3
0 - 1/8 in....		5.2		3.4
Av'g part.size in.	11.508	1.601	5.929	1.610
Size reduction...%		13.9		27.2

TABLE IV. Grindability

Screen Size of Coal Tested	Hardgrove* Index
Mine Run......	35.2
0 - 1-1/2 in..	37.3
0 - 1/2 in..	39.3

*See Appendix

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE V. Proximate Analyses, Calorific Value and Fusibility of Ash

Screen Sizes	Moisture (as rec'd) %	Dry Basis					Initial Deformation °F.	Softening-Temperature °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
		Ash %	Volatile Matter %	Fixed Carbon %	Sulphur %	Calorific Value Btu/lb.						
Plus 8 in..	16.4	9.2	39.4	51.4	0.5	11,620	1950	2000	2020	70	50	20
4 - 8 in..	16.0	9.5	35.7	54.8	0.5		1980	2040	2110	130	60	70
2 - 4 in..	13.6	8.8	37.1	54.1	0.5		1860	2020	2050	190	160	30
1½ - 2 in..	12.5	10.0	36.1	53.9	0.6		1920	2010	2070	150	90	60
1 - 1½ in..	13.3	10.1	36.0	53.9	0.6		1920	2000	2150	230	80	150
3/4 - 1 in..	13.2	10.3	36.1	53.6	0.7		1900	1970	2060	160	70	90
1/2 - 3/4 in..	14.5	10.7	36.2	53.1	0.7		1900	2000	2140	240	100	140
1/4 - 1/2 in..	15.2	10.7	35.7	53.6	0.8		1920	2010	2160	240	90	150
1/8 - 1/4 in..	16.3	10.8	35.6	53.6	0.7		1960	2010	2030	70	50	20
#48 - 1/8 in..	11.0	12.0	35.3	52.7	0.8		1940	2020	2150	210	80	130
0 - #48	4.6	16.6	34.0	49.4	0.5		1950	2060	2170	220	110	110
Mine Run....	15.6	9.9	36.6	53.5	0.6	11,615	1940	1990	2140	200	50	150
Plus 1½ in..	15.3	9.7	37.4	52.9	0.6	11,490	1950	2000	2140	190	50	140
0 - 1½ in..	16.0	10.8	36.2	53.0	0.7	11,410	1960	2010	2150	190	50	140
1/2 - 1½ in..	15.6	10.6	36.2	53.2	0.7	11,540	1950	2000	2150	200	50	150
0 - 1/2 in..	16.8	12.1	36.2	51.7	0.7	11,245	1980	2020	2030	50	40	10

Classification of Coal by Rank

Specific Volatile Index	106-Black Lignite
A.S.T.M. Classification	Subbituminous B

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE VI. Ultimate Analyses (Mine Run)

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %	Moisture %
As Received	57.2	3.8	0.5	1.2	13.4	8.3	15.6
Dry Basis	67.7	4.5	0.6	1.5	15.8	9.9	

TABLE VII. Chemical Analysis of Ash

Sample	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %	MnO %	Na_2O %	K_2O %	P_2O_5 %	TiO_2 %	SO_3 %	Total %
Mine Run	26.7	25.7	13.1	10.0	2.1	0.9	4.7	0.9	0.6	0.4	12.6	97.7

TABLE VIII. Swelling and Caking Properties

1. Coking Properties by "swelling" Index Test (1½" Slack)

Swelling Index............................	190
Section on Coke Classification Chart.....	XIII
Physical Properties of By-Product Coke...	NON-COKING

2. Caking Properties by Gray's Method (Mine Run)

Gray Caking Index.........................	NON-CAKING

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE IX. Float and Sink Data on $1\frac{1}{2}$ in. Slack
-Ash-

Specific Gravity	Weight	Ash	Cumulative				±.10 Specific Gravity Distribution	
			Floats		Sinks			
			Weight	Ash	Weight	Ash	Gravity	Calculated Ordinate
	%	%	%	%	%	%		
Floats 1.33	36.0	5.5	36.0	5.5	100.0	10.2	1.40	97.2
Sinks 1.33 " 1.40	55.7	8.1	91.7	7.1	64.0	12.9	1.45	14.4
" 1.40 " 1.50	3.0	17.8	94.7	7.4	8.3	45.0	1.55	2.1
" 1.50 " 1.60	1.0	31.0	95.7	7.7	5.3	60.4	1.65	1.0
" 1.60	4.3	67.2	100.0	10.2	4.3	67.2		
Curve No.	4	2	1, 2, 4	1	3	3	5	5

TABLE X. Chemical Analysis and Fusibility of Ash on Float and Sink Fractions of $1\frac{1}{2}$" Slack
(Dry Basis)

Specific Gravity	Ash %	Volatile Matter %	Fixed Carbon %	Coking Properties	Sulphur %	Initial Deformation °F.	Softening Point °F.	Fluid Temperature °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Floats 1.33	6.0	37.1	56.9	N.A.*	0.6	2000	2040	2160	160	40	120
Sinks 1.33 " 1.40	9.1	35.5	55.4	N.A.*	0.6	1940	1990	2010	70	50	20
" 1.40 " 1.50	19.1	35.7	45.2	N.A.*	1.3	1950	2000	2020	70	50	20
" 1.50 " 1.60	32.7	28.4	38.9	N.A.*	2.0	2160	2280	2520	360	120	240
" 1.60	69.2	21.6	9.2	N.A.*	1.1	2000	2060	2480	480	60	420

*Non-agglomerate

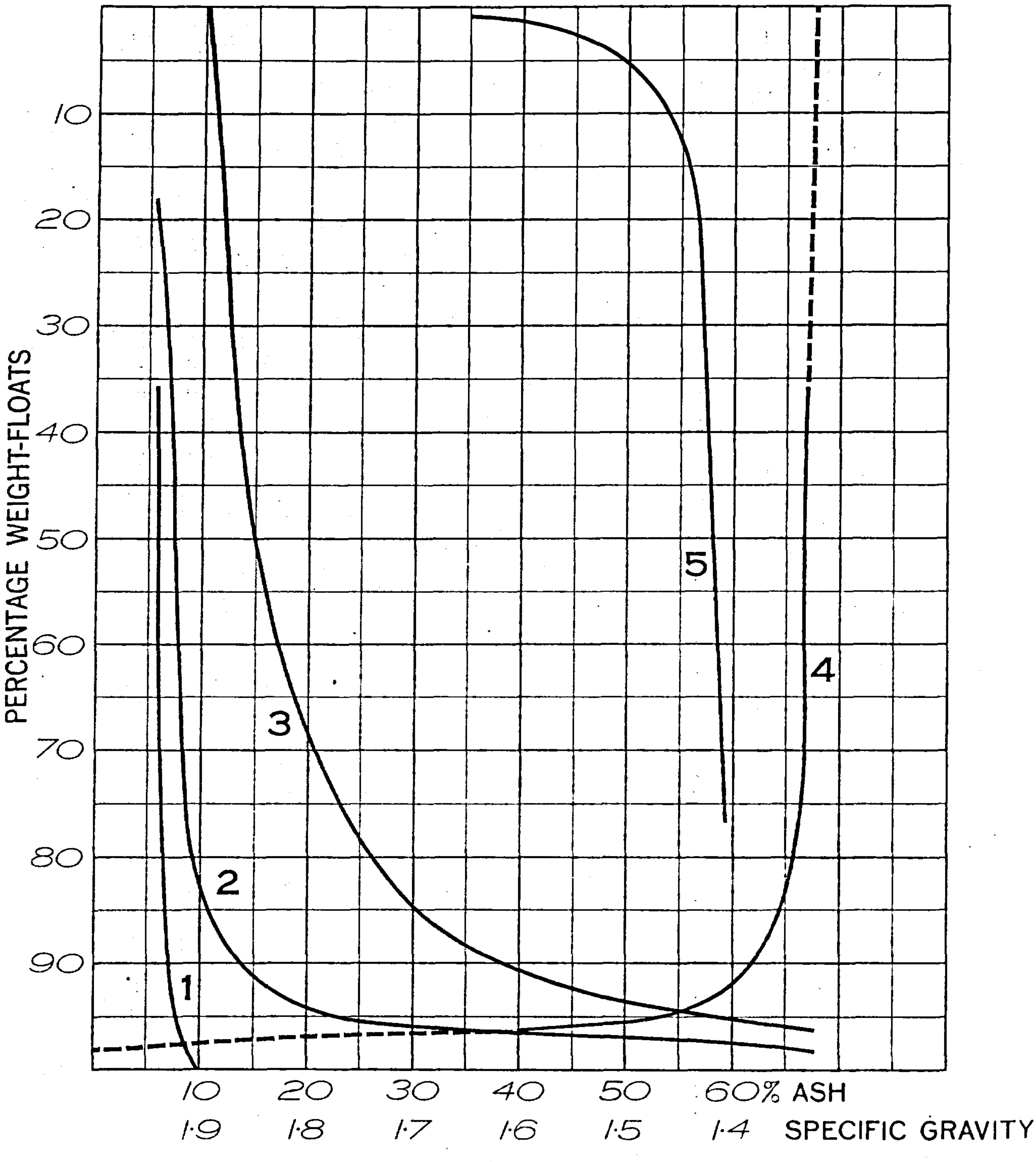

Figure 15 - Washability Curves for 1½ in. slack - No.3 seam, Atlas Mine.

Curve 1 - Cumulative coal-ash percentage (float).
Curve 2 - Actual ash percentage.
Curve 3 - Cumulative refuse-ash percentage (sink).
Curve 4 - Specific Gravity.
Curve 5 - ± .10 Specific gravity distribution.

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE XI. Float and Sink Data on $1\frac{1}{2}$-4 in. Lump

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.35	45.2	5.2	45.2	5.2	100.0	8.2
Sinks 1.35	" 1.40	52.2	8.9	97.4	7.2	54.8	10.7
" 1.40	" 1.50	1.2	18.7	98.6	7.3	2.6	47.7
" 1.50	" 1.60	0.0	0.0	98.6	7.3	1.4	72.5
" 1.60		1.4	72.5	100.0	8.2	1.4	72.5
Curve No.	4		2	1, 2, 4	1	3	3

TABLE XII. Float and Sink Data on Plus 4 in. Lump-Crushed

-Ash-

Specific Gravity		Weight	Ash	Cumulative Floats		Cumulative Sinks	
				Weight	Ash	Weight	Ash
		%	%	%	%	%	%
	Floats 1.35	31.6	5.8	31.6	5.8	100.0	7.4
Sinks 1.35	" 1.40	65.7	7.6	97.3	7.0	68.4	8.2
" 1.40	" 1.50	0.9	16.8	98.2	7.1	2.7	22.6
" 1.50	" 1.60	1.0	21.0	99.2	7.2	1.8	25.4
" 1.60		0.8	31.0	100.0	7.4	0.8	31.0
Curve No.	4		2	1, 2, 4	1	3	3

NO. 2 (EAST COULEE) SEAM - ATLAS MINE

TABLE XIII. Chemical Analyses of Raw Coal, Clean Coal and Refuse

0 to 1-1/2 Inch Slack

	Raw Coal	Clean Coal Floats 1.50	Refuse Sinks 1.50
Weight..........%	100.0	93.4	6.6
Proximate Analysis (dry basis)			
Ash..........%	10.8	7.8	57.9
Volatile Matter..........%	36.2	36.6	24.9
Fixed carbon..........%	53.0	55.6	17.2
Sulphur..........%	0.7	0.6	1.6
Calorific Value......B.T.U./lb.	11,410	11,725	4,545
Fusion Point of Ash..........°F.	2010	2020	2010
Melting Range of Ash..........°F.	190	190	130
Coking Properties..........:	N.A.*	N.A.*	N.A.*

*Non-agglomerate

TABLE XIV. Screen and Chemical Analyses of Sizes Prepared from 1½ in. Slack and Analyses of the Clean Coal and Refuse of these Sizes after Washing at a Gravity of 1.50

Screen Sizes	Weight %	Cum. Weight %	Ash %	Sulphur %	F.P.A. °F.	Floats Weight %	Floats Ash %	Floats F.P.A. °F.	Sinks Weight %	Sinks Ash %	Sinks F.P.A. °F.
1/2 - 1-1/2 inch	59.1	59.1	10.6	0.7	2000	91.8	7.9	2020	8.2	65.2	2000
0 - 1/2 inch	40.9	100.0	12.1	0.7	2020	92.3	7.3	2020	7.7	57.4	2000

Chapter IV

SUMMARY AND DISCUSSION OF RESULTS

All the coals mined in the Drumheller Area occur in the Edmonton formation and are so closely related, even though coming from different seams, that they may be conveniently compared as to their physical and chemical properties. However, in order to show the slight change or trend in properties from west to east the data is presented according to district.

Physical Properties

Size Distribution

The size distributions of the run-of-mine samples are shown in Table I under the respective mine designations. The average particle size calculated from the screen analyses in accordance with the method referred to in the Appendix and as shown in Table A is rather high for a mine-run coal and is indicative of a fairly large quantity of lump. The average particle size varies almost directly with the amount of plus 4 inch lump present, and it is of interest to note that for the same seam there appears to be only a slight variation in size from mine to mine. However the different seams appear to show a definite variation between themselves as indicated by the values below which are the average for each seam.

	Average Particle Size in.	+4 in. Lump %	Ox1½ in. Slack %
No. 1 Seam	5.36	60.4	17.6
No. 2 Seam	4.82	52.8	22.5
No. 5 Seam	4.82	54.2	26.9
No. 7 Seam	3.17	31.7	41.5

The average particle size and quantity of plus 4 inch lump appears to decrease and conversely the quantity of 0 to 1½ inch slack appears to increase with the relative position of the seam in the formation from bottom to top in the series.

Density

The apparent specific gravity and bulk density for each of the various sizes of coal from the different seams and mines are shown in Table I under the respective mine designations. Table B gives the minimum and maximum values obtained for characteristics for the coals in sizes from plus 4 inch to 1/8 inch. The results indicate that although there is some variation in the density characteristics for the various sizes of the same coal and for corresponding sizes of the different coals, the differences are not very great and not readily related to the ash contents which appear to vary to a far greater degree than the density characteristics.

TABLE A

COMPARATIVE SIZE DISTRIBUTION

District and Mine	Seam	Average Particle Size in.	+4 in. Lump %	0x1½ in. Slack %	0x1/8 in. Fines %
Drumheller District					
Newcastle	No.1	5.19	62.7	17.9	1.4
Red Deer Valley	No.1	5.52	56.5	18.0	1.3
Midland	No.1	4.49	49.4	26.6	2.9
Commander	No.1	5.87	63.3	19.0	2.1
Hy-Grade	No.1	5.66	64.0	13.3	0.9
Brilliant	No.1	5.26	64.7	13.6	1.4
Minute	No.7	3.17	31.7	41.5	5.1
Rosedale District					
Star	No.1	5.51	62.3	14.6	1.3
Rosedale	No.5	4.82	54.2	26.9	4.2
Arcadia	No.2	5.07	60.5	19.4	3.7
East Coulee District					
Murray	No.2	4.65	52.6	19.9	2.2
Western Crown	No.2	4.02	44.7	24.4	3.0
Atlas	No.2	5.55	53.3	26.2	3.1

TABLE B

COMPARATIVE DENSITIES

District and Mine	Seam	Apparent Specific Gravity	Bulk Density lb./cu.ft.	Ash %
Drumheller District				
Newcastle	No.1	1.36-1.42	42.4-51.0	10.9-21.5
Red Deer Valley	No.1	1.33-1.38	42.4-52.1	7.8-21.4
Midland	No.1	1.34-1.47	40.7-52.4	8.2-23.1
Commander	No.1	1.35-1.38	41.0-51.6	7.7-14.9
Hy-Grade	No.1	1.36-1.40	42.0-54.5	8.4-17.3
Brilliant	No.1	1.37-1.42	42.5-57.0	9.9-19.7
Minute	No.7	1.36-1.43	41.5-52.7	17.0-22.3
Rosedale District				
Star	No.1	1.34-1.39	37.2-52.5	9.2-15.7
Rosedale	No.5	1.35-1.41	41.5-56.8	10.2-31.5
Arcadia	No.2	1.34-1.35	41.0-51.4	6.6-12.7
East Coulee District				
Murray	No.2	1.38-1.41	40.6-51.7	8.5-13.7
Western Crown	No.2	1.35-1.40	41.8-50.0	8.6-17.1
Atlas	No.2	1.35-1.39	39.3-51.0	9.2-13.1

Blending the various sizes in different proportions results in mixtures having varying bulk densities higher than those of the individual sizes. Generally the bulk densities of the various size mixtures decrease with a decrease in the quantity and size of the larger lumps.

Size Stability (by Drop-Shatter Test)

The size degradation, after a standardized amount of handling, on a single size of each of the coals examined is shown in Table II under the respective mine designations. Table C below presents a summary of this data.

TABLE C

COMPARATIVE SIZE-STABILITY

District and Mine	Seam	Size Stability Per Cent (2 - 3 in. coal)	
		After 2 drops %	After 4 drops %
Drumheller District			
Newcastle	No.1	79.2	69.6
Red Deer Valley	No.1	83.2	74.4
Midland	No.1	82.4	74.8
Commander	No.1	70.8	59.2
Hy-Grade	No.1	79.2	70.4
Brilliant	No.1	79.6	70.0
Minute	No.7	75.2	65.2
Rosedale District			
Star	No.1	80.0	69.6
Rosedale	No.5	75.1	62.8
Arcadia	No.2	78.4	68.0
East Coulee District			
Murray	No.2	72.4	60.8
Western Crown	No.2	75.6	62.4
Atlas	No.2	73.7	62.4

Based on the calculated average particle size of the coal before and after the standard test, the stability of the coals are medium in value and fairly uniform throughout the whole field irrespective of the seam from which the samples originated. The No. 1 seam, however, appears to be somewhat more resistant, to handling, as indicated by either the reduction in size after two or four drops, as shown below.

	Size Stability Per Cent	
	After 2 drops	After 4 drops
No. 1 Seam	79.2	69.7
No. 2 Seam	75.0	63.4
No. 5 Seam	75.1	62.8
No. 7 Seam	75.2	65.2

In a general way the differences noted in the stability of the individual size tested is to a certain degree reflected in the average size of the coal mined, the higher the stability the larger is the average particle size of the run-of-mine coal. The relationship naturally is tempered to a greater or lesser degree by the method of mining, machine mining tending to the production of lumpier coal.

Grindability

The Hardgrove indices of grindability for three size mixtures of the Drumheller coals are shown in Table IV under the respective mine designations. Table D shows on a comparative basis these Hardgrove indices for the various sizes tested. These coals are not very susceptible to easy grinding as judged by the Hardgrove index, and it will be noted that there appears to be very little difference in the grinding characteristics of the various sizes irrespective of ash content. Also it is of interest to note that there is no apparent difference in the grinding characteristics of the various seams.

TABLE D

COMPARATIVE GRINDABILITIES

District and Mine	Hardgrove Grindability Index		
	Mine Run	0x1½ in.	0x1/2 in.
Drumheller District			
Newcastle	39.3(12.1)	38.0(13.2)	34.5(18.7)
Red Deer Valley	35.5(8.6)	34.5(12.6)	35.2(14.9)
Midland	35.9(12.6)	37.3(15.2)	36.9(17.4)
Commander	42.8(9.6)	42.5(12.1)	42.1(12.7)
Hy-Grade	35.2(9.4)	34.5(11.6)	35.2(14.1)
Brilliant	36.6(11.6)	36.6(14.6)	36.6(15.0)
Minute	36.6(15.8)	35.9(15.7)	37.3(17.7)
Rosedale District			
Star	36.9(10.1)	33.4(11.5)	33.8(12.7)
Rosedale	38.0(13.3)	38.6(14.8)	45.6(17.0)
Arcadia	36.6(8.6)	35.2(10.5)	34.5(11.3)
East Coulee District			
Murray	35.9(9.1)	37.3(10.9)	36.6(11.5)
Western Crown	35.5(11.1)	35.5(13.2)	35.2(14.1)
Atlas	35.2(9.9)	37.3(10.8)	39.3(12.1)

N.B. Values in brackets are the ash percentages on the dry basis.

Crushing Characteristics

The crushing characteristics for two sizes, namely the plus 8 inch lump, and the 4 to 8 inch lump, for the various coals are shown in Table III under the respective mine designations.

TABLE E

COMPARISON OF CRUSHING PROPERTIES

District and Mine	Plus 8 in. Lump						4-8 in. Lump					
	Average Particle Size		Size	Commercial Sizes Produced			Average Particle Size		Size	Commercial Sizes Produced		
	Before Crushing in.	After Crushing in.	Reduction %	Stove (1x3 in.) %	Stoker (½x1 in.) %	Slack (0x½ in.) %	Before Crushing in.	After Crushing in.	Reduction %	Stove (1x3 in.) %	Stoker (½x1 in.) %	Slack (0x½ in.) %
Drumheller												
Newcastle	9.00	1.65	18.3	54.3	14.5	19.9	6.11	1.70	27.9	57.9	15.1	14.6
Red Deer Valley	11.33	1.72	15.2	68.4	13.1	14.3	5.97	1.81	30.2	70.4	11.8	11.5
Midland	10.22	1.56	15.3	62.9	15.4	18.0	6.00	1.70	28.4	70.7	13.0	13.0
Commander	10.73	1.67	15.6	65.7	13.7	15.7	6.02	1.75	29.0	68.7	13.4	12.2
Hy-Grade	9.89	1.93	19.5	58.6	11.9	12.8	6.24	1.88	30.1	60.5	12.6	13.0
Brilliant	10.06	1.89	18.8	65.6	11.8	11.5	6.07	1.92	31.5	65.8	11.6	11.5
Minute	9.24	1.57	17.0	63.1	16.0	16.9	5.74	1.62	28.1	65.9	15.1	14.3
Rosedale												
Star	10.69	1.52	14.2	60.4	15.8	20.6	5.72	1.75	30.5	69.4	12.8	12.8
Rosedale	10.19	1.67	16.4	53.1	16.9	18.3	6.09	1.70	27.9	60.3	16.9	14.2
Arcadia	9.54	1.53	16.0	63.0	14.8	19.7	6.08	1.59	26.2	66.1	12.7	18.3
East Coulee												
Murray	9.44	1.55	16.4	60.3	14.6	20.7	5.79	1.63	28.1	67.8	14.0	15.7
Western Crown	9.84	1.47	14.9	58.5	18.1	20.0	5.80	1.56	26.8	65.1	16.6	15.5
Atlas	11.51	1.60	13.9	63.7	15.1	17.2	5.93	1.61	27.2	67.9	15.3	13.5

Table E presents this data for the various coals on a comparative basis showing the proportion of commercial sizes, such as stove (1x3 in.), stoker (½x1 in.), and slack (0x½ in.) that would be produced by crushing under the circumstances described previously.

Considering the plus 8 in. lump it is of importance to note that irrespective of the seam or mine from which the coal originated, when tested under the same conditions, the quantities of the commercial sizes produced on crushing does not vary to any great extent. This is shown below for the average for each seam.

	Commercial Sizes from Crushing Plus 8 in. Lumps - %		
	Stove	Stoker	Slack
No. 1 Seam	62.3	13.7	16.4
No. 2 Seam	61.4	15.7	19.4
No. 5 Seam	53.1	16.9	18.3
No. 7 Seam	63.1	16.0	16.9

Examination of the data in Table E also shows that crushing the 4 to 8 in. lump yields practically the same results in so far as relative quantities of sizes recovered is concerned, although there is somewhat more stove size produced and a proportionately lower amount of stoker and slack as shown below for the average.

	Commercial Sizes from Crushing 4-8 in Lumps - %		
	Stove	Stoker	Slack
No. 1 Seam	66.5	12.9	12.6
No. 2 Seam	66.7	14.7	15.7
No. 5 Seam	60.3	16.9	14.2
No. 7 Seam	65.9	15.1	14.3

Chemical Properties

Proximate Analyses

The proximate analyses of the various screened sizes and mixtures (composites) of the screen sizes for the Drumheller coals are shown in Table V under the respective mine designations. As the values obtained for the run-of-mine composites may be considered as representative, these analyses for the various mines are shown below in Table F for comparative purposes. It should be noted that the moisture values indicated on the "as received" basis, refers to the basis as received at these laboratories some time after sampling. Table G shows the moisture of the coals "as mined" and was obtained from fresh samples shipped in sealed containers to the laboratory.

TABLE F

COMPARISON OF PROXIMATE ANALYSES OF MINE RUN

District and Mine	Seam	Proximate Analyses			
		Moisture As Received %	Dry Basis		
			Volatile Matter %	Fixed Carbon %	Ash %
Drumheller District					
Newcastle	No.1	14.5	36.1	51.8	12.1
Red Deer Valley	No.1	15.6	35.9	55.5	8.6
Midland	No.1	14.9	35.0	52.4	12.6
Commander	No.1	13.8	37.0	53.4	9.6
Hy-Grade	No.1	15.4	36.5	54.1	9.4
Brilliant	No.1	14.9	37.2	51.2	11.6
Minute	No.7	15.3	33.9	50.3	15.8
Rosedale District					
Star	No.1	15.5	36.0	53.9	10.1
Rosedale	No.5	16.4	34.6	52.1	13.3
Arcadia	No.2	14.4	36.0	55.4	8.6
East Coulee District					
Murray	No.2	18.0	36.7	54.2	9.1
Western Crown	No.2	15.6	36.1	52.8	11.1
Atlas	No.2	15.6	36.6	53.5	9.9

TABLE G

COMPARISON OF "AS MINED" MOISTURE OF MINE RUN

District and Mine	Seam	Moisture - %	
		As Mined	As Received
Drumheller District			
Newcastle	No.1	17.9	14.5
Red Deer Valley	No.1	17.6	15.6
Midland	No.1	17.7	14.9
Commander	No.1	17.7	13.8
Hy-Grade	No.1	17.4	15.4
Brilliant	No.1	18.4	14.9
Minute	No.7	20.4	15.3
Rosedale District			
Star	No.1	19.1	15.5
Rosedale	No.5	20.2	16.4
Arcadia	No.2	19.9	14.4
East Coulee District			
Murray	No.2	19.7	18.0
Western Crown	No.2	19.1	15.6
Atlas	No.2	20.3	15.6

The data in Table F indicates, that in so far as the run-of-mine coal is concerned there appears to be very little difference in the proximate analysis between the seams and the mines in the three districts. However the moisture on the ' as mined' basis increases the higher the seam lies in the formation, as indicated below by the averages for the seams:-

	Moisture % - As mined
No. 1 Seam	18.0
No. 2 Seam	19.7
No. 5 Seam	20.2
No. 7 Seam	20.4

It is of interest to note also that the Drumheller coals appear to lose from 3.0% to 5.0% moisture from the 'as mined' basis over a period of several months when stored under cover without any apparent change in the appearance or physical quality of the coal. This would indicate that these coals could be stored under cover without any serious loss in "form value" as a result of size degradation.

An examination of the volatile matter calculated to the dry ash-free basis, as shown in Table H, indicates that there is very little difference organically between the various seams.

TABLE H

COMPARISON OF VOLATILE MATTER ON DRY ASH-FREE BASIS

District and Mine	Seam	Plus $1\frac{1}{2}$ in.	Ox$1\frac{1}{2}$ in.
Drumheller District			
Newcastle	No.1	40.5	40.3
Red Deer Valley	No.1	40.0	39.8
Midland	No.1	39.6	40.1
Commander	No.1	40.7	39.5
Hy-Grade	No.1	40.6	40.6
Brilliant	No.1	42.2	41.3
Minute	No.7	41.2	40.7
Rosedale District			
Star	No.1	41.2	41.8
Rosedale	No.5	39.9	39.2
Arcadia	No.2	39.9	41.2
East Coulee District			
Murray	No.2	43.3	41.9
Western Crown	No.2	40.6	42.5
Atlas	No.2	41.4	40.6

Generally speaking the ash contents of the various coals appear to increase to some extent with a decrease in size. This is evident from Table J below where the ash contents on the dry basis of the plus $1\frac{1}{2}$ in. lumps, $\frac{1}{2}$x$1\frac{1}{2}$ in., so-called pea-nut size, and the Ox$\frac{1}{2}$ in. slack are compared. It is of interest to note also that with few exceptions there is a fairly uniform difference in the ash contents of the various sizes from the different mines and seams.

TABLE J

COMPARISON OF ASH FOR MIXED SIZES

District and Mine	Seam	Plus 1½ in. (Lump)	½x1½ in. (Pea-nut)	0x½ in. (Slack)
		Ash (Dry Basis)		
		%	%	%
Drumheller District				
Newcastle	No.1	11.3	11.7	18.7
Red Deer Valley	No.1	8.2	11.7	14.9
Midland	No.1	10.0	14.0	17.4
Commander	No.1	9.2	13.1	12.7
Hy-Grade	No.1	8.4	9.3	14.1
Brilliant	No.1	10.9	12.3	15.0
Minute	No.7	15.8	14.0	17.7
Rosedale District				
Star	No.1	8.8	10.1	12.7
Rosedale	No.5	12.9	11.4	19.9*
Arcadia	No.2	7.3	9.8	11.3
East Coulee District				
Murray	No.2	8.8	11.0	11.5
Western Crown	No.2	10.1	11.9	14.1
Atlas	No.2	9.7	10.6	12.1

*Calculated.

Calorific Value

The calorific values for the various composites of screened sizes are shown in Table V under the separate designated mines. The average calorific values for the run-of-mine samples on the "as received", "dry" and "dry-ash free" bases are shown below in Table K.

TABLE K

COMPARISON OF CALORIFIC VALUES OF MINE RUN SAMPLES

District, Mine & Seam	Calorific Value (B.T.U./lb)			Moisture	Ash Dry Basis
	As Received	Dry Basis	Dry, Ash-Free Basis	%	%
Drumheller District					
Newcastle(No.1)	9,956	11,645	13,248	14.5	12.1
Red Deer Valley (No.1)	10,255	12,150	13,293	15.6	8.6
Midland(No.1)	9,731	11,435	13,084	14.9	12.6
Commander(No.1)	10,206	11,840	13,097	13.8	9.6
Hy-Grade(No.1)	10,207	12,065	13,317	15.4	9.4
Brilliant(No.1)	9,884	11,615	13,139	14.9	11.6
Minute(No.7)	9,165	10,820	12,850	15.3	15.8
Rosedale District					
Star(No.1)	10,030	11,870	13,204	15.5	10.1
Rosedale(No.5)	9,342	11,175	12,889	16.4	13.3
Arcadia(No.2)	10,152	11,860	12,976	14.4	8.6
East Coulee District					
Murray(No.2)	9,664	11,785	12,965	18.0	9.1
Western Crown(No.2)	9,765	11,570	13,015	15.6	11.1
Atlas(No.2)	9,803	11,615	12,891	15.6	9.9

The calorific values of three size mixtures namely, mine run, plus 1½ in. Lump and Ox½ in. slack on the dry, ash-free basis are presented in Table L.

TABLE L

COMPARISON OF CALORIFIC VALUES ON DRY, ASH-FREE BASIS

District, Mine & Seam	Calorific Value - B.T.U./lb. (Dry, ash-free basis)			
	Mine Run	Plus 1½ in.	Ox1½ in.	Average
Drumheller District				
Newcastle(No.1)	13,248	13,326	12,984	13,186
Red Deer Valley (No.1)	13,293	13,279	13,066	13,213
Midland(No.1)	13,084	13,106	12,972	13,054
Commander(No.1)	13,097	13,073	12,975	13,048
Hy-Grade(No.1)	13,317	13,221	12,992	13,177
Brilliant(No.1)	13,139	13,098	13,015	13,084
Minute(No.7)	12,850	12,993	12,912	12,918
Rosedale District				
Star(No.1)	13,204	13,185	12,994	13,128
Rosedale(No.5)	12,889	12,836	12,858	12,861
Arcadia(No.2)	12,976	13,053	12,966	12,998
East Coulee District				
Murray(No.2)	12,965	12,884	12,901	12,917
Western Crown(No.2)	13,015	12,981	12,926	12,974
Atlas(No.2)	12,891	12,724	12,791	12,802

Although on the "as received" basis there is a variation of over 1,000 B.T.U. between the maximum and minimum values, these large variations are due mainly to the difference in the moisture and ash contents of the coals, the results for the mine-run samples on the dry ash-free basis showing only a maximum variation of 443 B.T.U.

It is of interest to note referring to Table K, that in practically all cases the Ox½ in. slack on the dry, ash-free basis showed somewhat lower calorific values than the sizes retained on a ½ in. screen. On the average the Plus ½ in. sizes showed a calorific value of 13,066 B.T.U./lb. whereas the Ox½ in. fines exhibited a value of 13,950 B.T.U./lb.

There also appears to be a difference in calorific value from seam to seam, the value decreasing, although not regularly, from the bottom to the top seams in the formation, as indicated by the average calorific values on the dry-ash-free basis below:-

	Calorific Value - B.T.U./lb. Dry-Ash-Free Basis
Seam No. 1	13,127
Seam No. 2	12,923
Seam No. 5	12,861
Seam No. 7	12,918

It should be noted that in so far as proximate analyses and calorific values are concerned, the coal from the No. 5 seam appears to be out of place. As this sample was taken from a new development and thus not far from the outcrop it is quite possible that it was somewhat oxidized. This would account for the low volatile matter and calorific value on the dry-ash-free basis.

For comparative purposes Table M, below, gives the proximate analyses and calorific values of the mine run samples of all the coals on the "as mined" basis. On this basis most of the coals show less than 30% volatile matter, and less than 10,000 B.T.U./lb.

Ultimate Analyses

The ultimate analyses, that is, the carbon, hydrogen, sulphur, nitrogen and oxygen contents of the coals from the various mines are shown in Table VI under the respective mine designations. For comparative purposes the values obtained for the mine run samples on the dry basis are shown in Table N, and on the dry-ash-free basis in Table O.

TABLE M

COMPARISON OF ANALYSES OF MINE RUN SAMPLES ON THE "AS MINED" BASIS

District, Mine & Seam	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Calorific Value B.T.U./lb.
Drumheller District					
Newcastle(No.1)	17.9	9.9	29.6	42.6	9,561
Red Deer Valley (No.1)	17.6	7.1	29.6	45.7	10,011
Midland(No.1)	17.7	10.4	28.8	43.1	9,411
Commander(No.1)	17.7	7.9	30.5	43.9	9,744
Hy-Grade(No.1)	17.4	7.8	30.2	44.6	9,966
Brilliant(No.1)	18.4	9.5	30.4	41.7	9,478
Minute(No.7)	20.4	12.6	27.0	40.0	8,613
Rosedale District					
Star(No.1)	19.1	8.2	29.1	43.6	9,603
Rosedale(No.5)	20.2	10.6	27.6	41.6	8,918
Arcadia(No.2)	19.9	6.9	28.8	44.4	9,500
East Coulee District					
Murray(No.2)	19.7	7.3	29.5	43.5	9,463
Western Crown(No.2)	19.1	9.0	29.2	42.7	9,360
Atlas(No.2)	20.3	7.9	29.2	42.6	9,257

There does not appear to be a very great difference in the ultimate analyses of any of the coals, there being very little variation from mine to mine, or from one seam to another. The table below shows a comparison of the average data on the dry-ash-free basis for the four seams, and is not sufficiently indicative of any definite trend.

	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %
Seam No. 1	76.3	5.2	0.6	1.5	16.4
Seam No. 2	75.4	4.9	0.9	1.6	17.2
Seam No. 5	76.2	5.0	0.6	1.7	16.5
Seam No. 7	75.3	5.2	0.6	1.3	17.6

TABLE N

COMPARISON OF ULTIMATE ANALYSES

	Ultimate Analyses (Dry Basis)					
District, Mine & Seam	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %	Ash %
Drumheller District						
Newcastle(No.1)	67.2	4.5	0.6	1.4	14.2	12.1
Red Deer Valley (No.1)	68.4	4.8	0.5	1.4	16.3	8.6
Midland(No.1)	66.4	4.4	0.5	1.3	14.8	12.6
Commander(No.1)	69.3	4.7	0.4	1.3	14.7	9.6
Hy-Grade(No.1)	70.2	4.8	0.6	1.4	13.6	9.4
Brilliant(No.1)	67.4	4.6	0.4	1.3	14.7	11.6
Minute(No.7)	63.4	4.4	0.5	1.1	14.8	15.8
Rosedale District						
Star(No.1)	68.5	4.8	0.7	1.4	14.5	10.1
Rosedale(No.5)	66.1	4.3	0.5	1.5	14.3	13.3
Arcadia(No.2)	68.9	4.4	0.7	1.6	15.8	8.6
East Coulee District						
Murray(No.2)	68.5	4.4	0.7	1.3	16.0	9.1
Western Crown(No.2)	67.2	4.6	1.0	1.3	14.8	11.1
Atlas(No.2)	67.7	4.5	0.6	1.5	15.8	9.9

TABLE O

COMPARISON OF ULTIMATE ANALYSES (Dry-Ash-Free)

District, Mine & Seam	Ultimate Analyses (Dry-Ash-Free Basis)				
	Carbon %	Hydrogen %	Sulphur %	Nitrogen %	Oxygen %
Drumheller District					
Newcastle(No.1)	76.5	5.1	0.7	1.6	16.1
Red Deer Valley (No.1)	74.8	5.3	0.5	1.5	17.9
Midland(No.1)	76.0	5.0	0.6	1.5	16.9
Commander(No.1)	76.7	5.2	0.4	1.4	16.3
Hy-Grade(No.1)	77.5	5.3	0.7	1.5	15.0
Brilliant(No.1)	76.2	5.2	0.5	1.5	16.6
Minute(No.7)	75.3	5.2	0.6	1.3	17.6
Rosedale District					
Star(No.1)	76.2	5.3	0.8	1.6	16.1
Rosedale(No.5)	76.2	5.0	0.6	1.7	16.5
Arcadia(No.2)	75.4	4.8	0.8	1.8	17.2
East Coulee District					
Murray(No.2)	75.4	4.8	0.8	1.4	17.6
Western Crown(No.2)	75.6	5.2	1.1	1.5	16.6
Atlas(No.2)	75.1	5.0	0.7	1.7	17.5

TABLE P

COMPARISON OF ASH FUSIBILITIES
(Mine Run Samples)

District, Mine & Seam	Ash Fusibility					
	Initial Deformation °F.	Softening Temp. °F.	Fluid Temp. °F.	Melting Range °F.	Softening Interval °F.	Flow Interval °F.
Drumheller District						
Newcastle(No.1)	2200	2310	2480	280	110	170
Red Deer Valley (No.1)	2100	2220	2340	240	120	120
Midland(No.1)	2020	2280	2450	430	260	170
Commander(No.1)	2070	2150	2220	150	80	70
Hy-Grade(No.1)	1900	2220	2350	450	320	130
Brilliant(No.1)	2200	2300	2400	200	100	100
Minute(No.7)	2230	2420	2520	290	190	100
Rosedale District						
Star(No.1)	2160	2260	2340	180	100	80
Rosedale(No.5)	2300	2400	2450	150	100	50
Arcadia(No.2)	1950	2030	2140	190	80	110
East Coulee District						
Murray(No.2)	1910	2020	2220	310	110	200
Western Crown(No.2)	1980	2100	2170	190	120	70
Atlas(No.2)	1940	1990	2140	200	50	150

Fusibility of Ash

The fusibility of ash, which includes the temperature of initial deformation, the softening temperature and fluid temperature, as determined by the gas-furnace method in a reducing atmosphere, are shown in Table V under the respective mine designations. The temperature intervals between the above empirical points are also shown in Table V. For comparative purposes, the results obtained on the run-of-mine sample of each coal are shown in Table P.

The softening temperatures of the various coals are in the range of the low melting point ashes; and although there is very little variation between the sizes of the same coal, there is a definite variation from coal to coal the softening temperatures ranging from 1990°F. to 2420°F. This variation is more or less according to the seam, as shown below:-

	Ash Softening Temp. - °F. Mine Run	Ash %(dry)
No. 1 Seam	2250	10.6
No. 2 Seam	2035	9.7
No. 5 Seam	2400	13.3
No. 7 Seam	2420	15.8

There is no regular increase or decrease in ash fusibility with the position of the seam in the geological formation, but there does appear to be some relationship between the quantity of ash and the fusibility, the lower the ash content the lower the fusibility. This would appear to indicate that the extraneous ash maybe associated with some of the coals of a refractory nature and high in ash fusibility. This is indicated by the table below which gives the ash softening temperatures of the inherent and extraneous ashes for the various coals. (The inherent ash is the ash of the coal floating at a low gravity in the vicinity of 1.30, and the extraneous ash is that ash in the material sinking at a gravity of 1.50 or 1.60). The inherent ashes in all cases show a low ash softening temperature, whereas the extraneous ashes for No. 1 Seam and No. 7 Seam are high and that No. 2 Seam low to medium. Thus the ash fusibility is apparently determined by the quantity and quality of extraneous ash present in the coal.

	Ash Softening Temp. - °F.	
Mine & Seam	Inherent Ash	Extraneous Ash
Newcastle(No. 1)	2050	2560
Red Deer Valley(No.1)	2040	2270
Midland(No.1)	2000	2630
Commander(No.1)	2080	2470
Hy-Grade(No.1)	2020	2560
Brilliant(No.1)	2130	2500
Minute(No.7)	2080	2630
Star(No.1)	2150	2280
Arcadia(No.2)	1950	2310
Murray(No.2)	2100	2140
Western Crown(No.2)	2070	2200
Atlas(No.2)	2040	2280

Chemical Analyses of the Ash

Table VII for each of the Drumheller coals shows the chemical analyses of the ashes of the mine-run sample. For comparative purposes the analyses of all the ashes are presented below in Table Q.

Generally speaking the ashes have a fairly high refractory content judged by the quantity of silica and alumina and a low iron oxide content. The relatively low to medium ash fusibility temperature is accounted for by the relatively high lime and alkali content. This type of ash should result in rather a porous friable clinker.

TABLE Q

COMPARISON OF ASH ANALYSES
(Mine Run Samples)

District, Mine & Seam	Ash Analyses						Soft. Temp. of Ash °F.
	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	$Na_2O + K_2O$ %	
Drumheller District							
Newcastle(No.I)	54.8	23.2	4.8	7.0	2.2	4.6	2310
Red Deer Valley (No.1)	51.2	20.7	4.7	8.7	2.4	5.0	2220
Midland(No.1)	48.4	20.1	9.6	8.8	2.0	2.9	2280
Commander(No.1)	42.9	21.2	15.0	8.3	2.3	5.1	2150
Hy-Grade(No.1)	48.0	21.0	6.5	10.6	2.0	5.7	2220
Brilliant(No.1)	52.5	22.8	4.9	8.5	2.1	4.7	2300
Minute(No.7)	55.5	22.8	3.6	6.1	0.5	4.7	2420
Rosedale District							
Star(No.1)	45.4	21.4	6.5	9.0	1.7	5.0	2260
Rosedale(No.5)	48.3	26.0	1.9	7.8	1.1	7.7	2400
Arcadia(No.2)	47.6	16.8	5.0	10.3	1.8	6.3	2030
East Coulee District							
Murray(No.2)	33.8	23.4	10.2	11.3	1.9	7.0	2020
Western Crown(No.2)	47.2	17.0	10.1	7.4	1.4	5.7	2100
Atlas(No.2)	26.7	13.1	25 7	10.0	2.1	5.6	1990

The difference in the ash characteristics of the various coal seams studied is shown below:-

	Ash Analyses						Soft.Temp. of Ash °F.
	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	Na_2O+K_2O %	
No. 1 Seam	49.0	21.5	7.4	8.7	2.1	4.7	2245
No. 2 Seam	38.8	17.6	12.8	9.8	1.8	6.1	2035
No. 5 Seam	48.3	26.0	1.9	7.8	1.1	7.7	2400
No. 7 Seam	55.5	22.8	3.6	6.1	0.5	4.7	2420

The above data indicates rather clearly the relationship of the ash constitution to the ash fusibility. No. 2 seam ash with the lowest fusibility contains the lowest quantity of refractory and the largest amount of iron oxide and lime. Even small differences in ash fusibility within the group of coals in the No. 2 seam may be accounted for by the ratio of refractories to fluxing materials. It may be assumed, as a result of experiments conducted on a series of coals relating clinker formation to ash constitution, that the No. 2 seam coals with the higher iron oxide content would yield a somewhat tougher, and less porous clinker than the coals of the other seams studied.

Classification by Rank

The ranks of the coals in the Drumheller area as judged by the S.V.I. (Specific Volatile Index) system of classification and by the A.S.T.M. method are shown in Table V under the respective mine designations. The S.V.I. classification is usually considered specially suitable for use in classifying coals for the by-product coking industry, but has been found to be very adaptable for general classification, especially for certain borderline coals. The A.S.T.M. method, based on the fixed carbon and calorific value of the pure coal, has been internationally adopted for the scientific classification of North American coals. Table R gives a comparison of the rank of all the coals by both systems of classification.

According to the S.V.I. method of classification all the coals are so-called Black Lignites, whereas according to the A.S.T.M. classification all the coals are Subbituminous B, with some bordering on the Subbituminous A class.

The specific volatile index allows for some differentiation in rank to be made within the same class or group. The table below shows the average of the rank of coals for each seam by this index.

	Specific Volatile Index
No. 1 Seam	116
No. 2 Seam	107
No. 5 Seam	109
No. 7 Seam	108

From the above it appears that the No. 1 Seam is slightly higher in rank than the other seams. Insufficient samples of No. 5 and No. 7 were available to get an average but the indications are that Nos. 2, 5, and 7 seams have the same rank. This is borne out by the other characteristics of the coal which indicate differences in rank such as the "as mined" moisture and calorific values.

TABLE R

COMPARISON OF THE RANK OF THE COALS

District, Mine & Seam	S.V.I. Classification		A.S.T.M. Classification
	S.V.I.	Group	
Drumheller District			
Newcastle(No.1)	118	Black Lignite	Subbituminous B to A
Red Deer Valley (No.1)	117	Black Lignite	Subbituminous B
Midland(No.1)	113	Black Lignite	Subbituminous B
Commander(No.1)	113	Black Lignite	Subbituminous B
Hy-Grade(No.1)	118	Black Lignite	Subbituminous B
Brilliant(No.1)	116	Black Lignite	Subbituminous B
Minute(No.7)	108	Black Lignite	Subbituminous B
Rosedale District			
Star(No.1)	115	Black Lignite	Subbituminous B
Rosedale(No.5)	109	Black Lignite	Subbituminous B
Arcadia(No.2)	110	Black Lignite	Subbituminous B
East Coulee District			
Murray(No.2)	110	Black Lignite	Subbituminous B
Western Crown(No.2)	104	Black Lignite	Subbituminous B
Atlas(No.2)	106	Black Lignite	Subbituminous B

Washing Characteristics

Laboratory washing tests on the coals from the various mines in the Drumheller coalfield were conducted in the standard manner on the $1\frac{1}{2}$ inch slack, $1\frac{1}{2}$ to 4 inch lumps and on the plus 4 inch lump crushed in a crusher set at $1\frac{1}{2}$ inches. The results obtained are shown in a series of tables and curves for each coal in Chapter III.

Float-and-Sink Data for $1\frac{1}{2}$ inch Slack

The data obtained by the float-and-sink tests with respect to ash and sulphur for the $1\frac{1}{2}$ inch slack sizes are given in Tables IX and X under the respective mine designations. The inherent ash and sulphur contents, as indicated by the analyses of the fractions floating at the lowest specific gravity are shown in the Table S.

The inherent ash contents of the coals are fairly high and more or less uniform, and the yield of relatively pure coal is comparatively high but not very uniform. In comparison to many bituminous coals tested the separation for the preparation of the lowest ash coal takes place at a somewhat higher gravity. The inherent sulphur content of all the coals was very low and approached the total sulphur content of the raw coal. This is due to the fact that these coals contain practically no inorganic sulphur.

Float-and-Sink Data for $1\frac{1}{2}$ to 4 in. and Plus 4 in. (crushed) Lumps

The data obtained by the float-and-sink tests for these two sizes of coal are given in Tables XI and XII respectively under the respective mine designations. The inherent ash contents and recovery as indicated by the fractions floating at the lowest specific gravity are shown in Table T.

TABLE S

COMPARISON OF THE INHERENT ASH AND SULPHUR
(0 - 1½ in.Slack)

District, Mine & Seam	Inherent Ash and Sulphur		Coal recovery at Lowest Specific Gravity* Percent of total	Ash in Unwashed Coal %
	Ash %	Sulphur %		
Drumheller District				
Newcastle(No.1)	5.0	0.6	35.2 (1.33)	13.2
Red Deer Valley (No.1)	4.4	0.5	52.1 (1.33)	13.5
Midland(No.1)	4.1	0.5	44.3 (1.33)	12.4
Commander(No.1)	4.9	0.5	50.5 (1.35)	9.9
Hy-Grade(No.1)	4.5	0.6	43.6 (1.33)	10.0
Brilliant(No.1)	5.2	0.5	27.2 (1.32)	11.3
Minute(No.7)	3.8	0.6	48.0 (1.33)	12.9
Rosedale District				
Star(No.1)	5.0	0.9	55.4 (1.33)	8.9
Rosedale(No.5)	3.5	0.5	5.6 (1.32)	12.0(1)
Arcadia(No.2)	5.0	0.7	65.9 (1.34)	9.4
East Coulee District				
Murray(No.2)	5.6	0.9	29.8 (1.33)	10.0
Western Crown(No.2)	4.8	0.8	44.3 (1.33)	11.8
Atlas(No.2)	5.5	0.6	36.0 (1.33)	10.2

*Specific gravity of separation in brackets.
(1) These data are on the 1/8 - 1½ in. size.

As in the case of the 1½ in. slack the lowest gravity of separation is rather high, varying from 1.32 to 1.35, and the inherent ash content is also high, though more or less uniform for all the coals tested. The quantity of relatively pure coal recovered varies from low to high depending upon the relative cleanliness of the raw coal.

Washing at a Selected Gravity

Simple wet washing, effected at a gravity as indicated by a value of 10% on the ± .10 specific gravity distribution curves was conducted on all the 1½ inch slacks. The results of washing the slacks are presented in Table XIII for each of the coals. Table U, below, shows on a comparative basis the ash contents of the 1½ in. slacks beofre and after washing and also gives the recovery and gravity of separation.

Simple wet washing in practically all cases was effected at a gravity of 1.50 with the preparation of a clean coal

TABLE T

COMPARISON OF INHERENT ASH OF LUMP SIZES

District, Mine & Seam	1½ - 4 in. Lump Recovery at Lowest Gravity %	1½ - 4 in. Lump Ash %	Plus 4 in. Lump Recovery at Lowest Gravity %	Plus 4 in. Lump Ash %
Drumheller District				
Newcastle(No.1)	47.8	5.1	25.4	5.4
Red Deer Valley (No.1)	52.1	5.0	55.5	4.8
Midland(No.1)	40.7	4.8	29.0	4.4
Commander(No.1)	19.7	5.0	34.3	5.4
Hy-Grade(No.1)	69.7	5.2	63.2	5.9
Brilliant(No.1)	33.1	5.2	23.2	6.9
Minute(No.7)	59.3	3.7	26.8	3.8
Rosedale District				
Star(No.1)	61.1	4.8	49.3	5.7
Rosedale(No.5)	13.0	3.6	11.9	3.9
Arcadia(No.2)	77.2	5.5	61.9	5.5
East Coulee District				
Murray(No.2)	42.1	5.6	25.2	5.7
Western Crown(No.2)	50.1	5.9	57.9	5.5
Atlas(No.2)	45.2	5.2	31.6	5.8

TABLE U

COMPARISON OF WASHED COAL
(0 - 1½ in. Slack)

District, Mine & Seam	Ash Content-% Raw Coal	Ash Content-% Clean Coal	Clean Coal Reclaimed %	Gravity of Separation
Drumheller District				
Newcastle(No.1)	13.2	9.9	90.0	1.50
Red Deer Valley (No.1)	12.6	7.3	91.8	1.50
Midland(No.1)	13.6	7.5	88.5	1.50
Commander(No.1)	12.1	8.2	92.2	1.50
Hy-Grade(No.1)	11.6	8.2	93.8	1.50
Brilliant(No.1)	14.6	10.5	91.5	1.50
Minute(No.7)	14.0	8.7	90.7	1.55
Rosedale District				
Star(No.1)	11.5	7.7	94.8	1.45
Rosedale(No.5)	12.6	9.0	93.0	1.60(1)
Arcadia(No.2)	10.5	6.5	92.5	1.45
East Coulee District				
Murray(No.2)	10.9	8.1	94.4	1.50
Western Crown(No.2)	13.2	9.2	93.2	1.55
Atlas(No.2)	10.8	7.8	93.4	1.50

(1) Data for this coal on 1/8 - 1½ in. size.

varying between 6.5% and 10.5% in ash, with an average of 8.3% for all the coals from coal containing on the average 12.5% ash as mined. The quantity of clean coal reclaimed varied between 88.5% and 94.8% of the raw coal and on the average approximately 92.3% of the raw coal. The refuse varied in ash content from 55.8% to 76.0% with an average of 63.9% for all the coals.

Simple wet washing of either the 1½ - 4 in. lumps or the plus 4 in. crushed lumps at a gravity of 1.60 effected very little improvement in the coal because of the high inherent ash and comparatively low total ash of the raw coal. This is shown in Table W, where in all cases there was very little or no material sinking in 1.60.

TABLE W

COMPARISON OF WASHED COAL OF LUMP SIZES

District, Mine & Seam	1½ - 4 in. Lump			+4 in. Lump-Crushed		
	Clean Coal %	Ash - % Clean	Ash - % Raw	Clean Coal %	Ash - % Clean	Ash - % Raw
Drumheller District						
Newcastle(No.1)	97.5	9.0	9.8	99.8	9.3	9.3
Red Deer Valley (No.1)	96.8	6.9	9.1	99.5	6.6	6.8
Midland(No.1)	97.1	8.1	10.0	99.7	8.9	9.0
Commander(No.1)	99.2	7.4	7.8	99.7	6.7	6.8
Hy-Grade(No.1)	99.8	7.7	7.8	99.2	7.6	7.8
Brilliant(No.1)	98.5	9.2	9.6	98.9	9.7	10.1
Minute(No.7)	98.4	9.1	9.4	98.8	11.9	12.3
Rosedale District						
Star(No.1)	99.4	7.0	7.4	100.0	7.2	7.2
Rosedale(No.5)	97.8	7.1	8.3	99.1	8.9	9.4
Arcadia(No.2)	99.1	6.4	7.1	100.0	6.3	6.3
East Coulee District						
Murray(No.2)	100.0	7.3	7.3	100.0	7.0	7.0
Western Crown(No.2)	97.6	8.9	10.2	99.8	8.2	8.2
Atlas(No.2)	98.6	7.3	8.2	99.2	7.2	7.4

Generally speaking it may be concluded that the Drumheller coals do not lend themselves readily to cleaning because of the high inherent ash. Only in cases where large quantities of free rock may be present would cleaning be warranted.

In the above discussion it should be noted that all data has been presented on the "as received" basis that is on the coal with about 15.0% moisture.

Swelling and Caking Properties

The coking properties of the coals from the Drumheller area as indicated by their swelling and caking properties are shown in Table VIII under the respective mine designations.

The results of the Swelling Index Test and the Gray Caking Index are shown on a comparative basis in Table Y.

TABLE Y

COMPARISON OF COKING PROPERTIES
(0 - $1\frac{1}{2}$ in. Slack)

District, Mine & Seam	Swelling Properties: Swelling Index	Swelling Properties: Remarks	Caking Properties: Gray Caking Index
Drumheller District			
Newcastle(No.1)	-140	Non-coking	Non-caking
Red Deer Valley (No.1)	-175	Non-coking	Non-caking
Midland(No.1)	-190	Non-coking	Non-caking
Commander(No.1)	-180	Non-coking	Non-caking
Hy-Grade(No.1)	-145	Non-coking	Non-caking
Brilliant(No.1)	-175	Non-coking	Non-caking
Minute(No.7)	-200	Non-coking	Non-caking
Rosedale District			
Star(No.1)	-175	Non-coking	Non-caking
Rosedale(No.5)	-125	Non-coking	Non-caking
Arcadia(No.2)	-165	Non-coking	Non-caking
East Coulee District			
Murray(No.2)	110	Non-coking	Non-caking
Western Crown(No.2)	-165	Non-coking	Non-caking
Atlas(No.2)	190	Non-coking	Non-caking

According to both these tests all the coals are absolutely non-caking, and according to the Swelling Index Test, they actually shrink appreciably in volume and retain their pulverized state on pyrolysis in the absence of oxygen.

Appendix

DESCRIPTION AND SIGNIFICANCE OF TESTS EMPLOYED IN PHYSICAL AND CHEMICAL SURVEY OF COALS FROM CANADIAN COLLIERIES (BUREAU OF MINES - MEMORANDUM SERIES)

The various tests described herein were employed at the Fuel Research Laboratories for studying the chemical and physical characteristics of (ton-lot) samples of coal from Canadian collieries. The data obtained by these tests have served for making a comparative scientific and economic evaluation of the coals examined.

Tests For Physical Properties

Size Distribution By Screen Analysis

The size distribution of the (run-of-mine) coal samples was determined, with slight modifications where necessary, according to the Tentative Method of Test for Screen Analysis of Coal, A.S.T.M. Designation D 410-35T, as described in the A.S.T.M. publication "Standards on Coal and Coke" prepared by Committee D-5, October 1938. Screens from the following series were used:-

1. Round-hole screens:- Plate screens with 4, 3, 2, 1½, 1, 3/4, 1/2, 1/4 and 1/8 inch diameter openings; and

2. Sieves:- Wire-cloth Tyler sieves with square openings of 10, 20, 48, 60 and 100 meshes to the linear inch. The nearest equivalent A.S.T.M. designations for the above sieves are respectively: 1680, 840, 297, 250 and 149 microns (A.S.T.M. Designation E-11)

It is becoming increasingly evident that the performance of mechanical stokers, gas producers, and other coal burning appliances are dependent not only on the average and 'absolute' size of the fuel used but also on the size distribution or range of sizes, and fuel technologists are conducting considerable research on this subject. Bennett (1) has shown how the problem can be attacked by studying the physical nature of the process of breakage of coal and by making use of Rosin and Rammler's law, which governs the distribution of size in the material obtained in the course of its mining and subsequent breakage. Since the application to coal of that law is still a subject of discussion, the 'size distribution' and 'absolute size' constants have not been generally utilized. However, in order to compare the screen analyses of the different physical and chemical survey samples, the average size of the coal has been calculated according to the method used by Smith (2) (5).

where the percentage weight of each screen size is multiplied by its respective average screen hole diameter in inches, the sum total being the average (particle) size of the coal.

Density

Apparent specific gravity, or 'lump' density, equals the weight of unit volume of the solid fuel as a lump, including cracks and fissures, ash and moisture. This physical property was determined by a modification of the A.S.T.M. method for coke as outlined under A.S.T.M. Designation D 167-24. The modified apparatus and procedure as developed by the Fuel Research Laboratories, has been reported in R.I.C.S. No. 35(3), as yet unpublished.

Bulk density equals the weight of the dry, or wet fuel contained in a unit volume of packing space. This physical characteristic was determined according to the Standard Method of Test For Cubic Foot Weight of Crushed Bituminous Coal, A.S.T.M. Designation D 291-29.

The bulk density is a characteristic of coal which has a bearing upon the filling of such spaces as bunkers, freight cars, coke oven chambers, etc., and upon the storage of a given number of heat units within a given volume. The bulk density of a coal depends upon various factors such as apparent specific gravity, particle size distribution, shape of particles, moisture content, thickness of bed, relation between mean particle size and dimensions of layer duration of storage and mode of packing (height of fuel shaking, stamping, etc.) Hence, as pointed out by Rosin (4), it is evident that bulk density is not a "property of substance and is no exact characteristic" but a resultant of various factors.

The bulk density of a coal will be equal to its lump density (apparent specific gravity) if the interspaces between the grains become so small that they are completely filled by the adherent water retained by the capillary forces acting in the minute interspaces.

'Void' is the interspace volume between the coal particles. It is calculated as a percentage from:

$$1 - \left(\frac{\text{bulk density}}{62.5 \times \text{apparent specific gravity}} \right. \times 100$$

and is highest for a bed consisting of particles of equal size. It increases, however, inversely with the volume factor.

The relations between particle size, moisture, bulk density and 'void' are of great significance, especially for carbonization, on account of their influence on packing, heat transfer and formation of the plastic layer. These relations are also fundamental in considering the following:- the de-watering of coal by drainage, shaking or centrifuging; the preparation of coal-oil mixtures; the dust-proofing of coal by oil spraying; the pitch consumption in briquetting; and the determination of the most economical compromise between the viscosity of a coal-oil mixture and the velocity of the reaction in the hydrogenation of coal.

Size Stability (and Friability)

Coal is a brittle heterogeneous material containing cracks and fissures. When a brittle material such as this, which varies in strength, is subjected to forces large enough to cause fracture, it breaks up into smaller pieces of varying sizes. This readiness of coal to break into smaller pieces is termed 'friability', which is a complex physical characteristic implying size degradation. The antonym of 'friability', as applied to coal, is 'size stability', and this may be considered to be a measure of the handling properties or resistance to breakage of the coal, either as an aggregate of lumps of the same size, or as a mixture of sizes. In the physical and chemical survey reports the term 'size stability' rather than 'friability' has been employed.

Methods for determining the comparative handling properties oc coal were devised and tested at the Fuel Research Laboratories in connection with the programme of the 'Coal Firability' Sub-Committee of the American Society for Testing Materials (5). The Drop Shatter Test for Coal which is an A.S.T.M. Tentative Standard (6), has been used in this investigation for determining the comparative size stability (and friability) of certain sizes and mixtures of sizes. Friability per cent is 100 - size stability per cent.

Grindability

The grindability, or ease of pulverizing a material, is not a single physical property but is a composite factor dependent upon a combination of such properties as strength, brittleness, hardness, etc. This factor was determined by the Tentative Method of Test for Grindability of Coal by the Hardgrove-machine Method, A.S.T.M. Designation D 409-37T. The method gives a measure of the relative grindability of any coal in comparison with a standard coal chosen as 100 grindability. The coal chosen as a standard is a low volatile run-of-mine product from Jerome mine, Upper Kittanning bed, Somerset county, Pennsylvania. The method is based on Rittinger's law(7), which states "The work done in pulverizing is proportional to the new surface produced". A sized sample receives a definite amount of grinding energy in a miniature pulverizer and the new surface is determined by sieving, greater resistance to grinding being indicated by lower values.

Grindability figures refer only to any given or constant grinding system and cannot be generalized to include other systems. Inasmuch as the term 'grindability' implies a combination of a group of physical properties and technical factors, the latter prevailing to a marked extent, no absolute scale of grindability to all grinding machines can be established. According to Rosin(4), "certain relations exist between particle size, power consumption and throughput, but they are greatly modified and completely masked by the machine factor, 99 per cent of the power consumption in pulverizers not being utilized for disintegration".

Some of the factors, other than 'grindability', that influence industrial capacity of pulverizers are moisture and size of coal. According to an article "Factors in Economical Grinding and Pulverizing" (8), when mills of any type are operated without air-drying of the coal "the effect of the surface moisture becomes important as increase in moisture decreases the output disproportionately. The general effect is to cause clogging of the fine material and prevent its removal by the air current so that the efficiency of the mill is lowered." The effect varies with different types of mills, being greatest with slow-speed mills of the ball-mill type and smallest with the impact or beater pulverizers. Increasing the size of the feed normally tends to decrease the output and the efficiency of pulverizers.

Tests For Chemical (and Physico-chemical) Properties

The various screened sizes of coal and the so-called 'composites' (re-assembled screened sizes) were subjected to chemical and physico-chemical analyses as outlined below.

Proximate Analyses

According to Bone(10), "the usefulness of any given coal for a particular purpose depends largely upon the yield of combustible 'volatile' matter expelled when it is carbonized under certain specified conditions and upon the character of the resulting carbonaceous residue. From a properly conducted laboratory test (ordinarily known as 'proximate analysis') much valuable information may be gained respecting the economic value of a given coal". A.S.T.M. Designation D 121-30, Standard Definitions of Terms Relating to Coal and Coke, defines proximate analysis as the determination, by prescribed methods, of moisture, volatile matter, fixed carbon and ash.

The American Society for Testing Materials has devised standard methods for proximate analysis, which are published as Standard Methods of Laboratory Sampling and Analysis of Coal and Coke, under A.S.T.M. Designation D 271-37. The Fuel Research Laboratories, however, for various reasons have retained slight modifications of these methods of analysis, but they do not vary to any great degree from the standards adopted by the A.S.T.M.

Moisture--For determining the moisture of a coal that is the moisture retained after sufficient drying to allow for crushing and grinding, one-gram quantities of the finely pulverized coal were dried for 105 minutes in small metal capsules. The drying was effected in a suitably constructed oven heated with toluene vapour at a temperature of between 105 and 108°C., with a current of preheated and dried carbon dioxide sweeping over the coal samples. The A.S.T.M. standard specifies air instead of CO_2, otherwise the method used corresponds to the published standard.

In the survey, only the moisture, as determined above, has been included, although the influence of surface or extraneous moisture on the use of coal for various purposes is of real importance. As this extraneous moisture is, however, dependent upon many factors such as storage, drainage, change of atmospheric conditions, etc., a study of the surface moisture of the seam samples in a general survey would not be of any significance.

Ash--The ash was determined according to the standard method described under A.S.T.M. Designation D271-37. One gram of the finely pulverized coal is ignited in an electric muffle at a controlled temperature between 700 and 750°C. The residual incombustible matter, which is a complex mixture of compounds resulting from the dehydration and ignition of the inorganic impurities present in the coal, is reported as ash.

Volatile Matter--The volatile matter of the coal was determined according to the A.S.T.M. method Designation D 271-37, with the exception that a Chaddock gas burner was employed in preference to either a Meker burner or a vertical electric furnace. The method consists of placing one gram of the sample in a covered platinum crucible and heating it over the Chaddock burner for a period of exactly seven minutes, the flame being so regulated as to give a temperature of 950°C +20°C. The loss of weight minus the moisture equals the volatile matter.

Fixed Carbon--The fixed carbon, which is that material remaining after the evolution of the moisture and volatile matter exclusive of ash, is calculated as follows:
100 -(moisture + ash + volatile matter)= percentage of fixed carbon

Ultimate Analyses

In A.S.T.M. Designation D 121-30, ultimate analysis is defined as the "determination of carbon and hydrogen in the material, as found in the gaseous products of its complete combustion, the determination of sulphur, nitrogen and ash in the material as a whole, and the estimation of oxygen by difference.

Total Sulphur--The total sulphur content of the coals, was determined according to the Eschka method as described under A.S.T.M. Designation D 271-37, with the exception that the sample was ignited at 700 to 750°C. instead of at the specified 800°C. ±25°C. with the Eschka mixture. The sulphates were then leached out and determined gravimetrically by precipitation with $BaSO_4$, as specified.

Carbon and Hydrogen--The determination of carbon and hydrogen was made by a procedure corresponding to A.S.T.M. Designation D 271-37, using an electrically-heated combustion furnace.

Nitrogen--The Kjeldahl-Gunning method, as recommended under A.S.T.M. Designation D 271-37 was employed for determining the nitrogen in the coals.

Oxygen--As there is no satisfactory direct method for determining oxygen, it was estimated by subtracting the sum of the percentage of hydrogen, carbon, nitrogen, sulphur and ash from 100. This result is, of course, effected by any errors incurred in the other determinations.

Calorific Value

The gross calorific value of coal, according to A.S.T.M. Designation D 407-35T, is "the heat produced by combustion of unit quantity, at constant volume, in an oxygen bomb calorimeter under specified conditions". This value was determined with the Emerson bomb according to the method described under A.S.T.M. Designation D 271-37.

The calorific value of a coal is an important factor in its evaluation for steam raising purposes, as well as for the determination of its rank. The purchase of coal on a heat value basis for steam raising has generally given satisfaction, and as aptly stated by Grumell (10) "the knowledge and experience acquired by systematic evaluation leads to better control of subsequent fuel deliveries and, in most cases, to more efficient performance in the boiler plant". The average calorific value of a coal seam, calculated to the dry ash-free (or mineral-matter-free) basis, can be generally used as a check on commercial determinations. It should be noted, however, that calorific value alone is not entirely sufficient for comparative purposes, as the satisfactory use of a coal often depends upon other factors as well, such as moisture, ash, volatile matter, coking properties, size friability, and possibly the melting point of ash.

Fusibility of Ash

The fusibility of the ashes of the coals was determined by the standard method outlined in A.S.T.M. Designation D 271-37, using a modified Remmey fusion test furnace heated with acetylene and oxygen. By means of this method, three different physical states of the ash cone under the influence of increasing temperatures are recorded.

1. The Initial Deformation Temperature--the temperature at which the apex of the cone begins to round or bend;

2. The Softening Temperature--the temperature at which the cone fuses down to a spherical shape; and

3. The Fluid Temperature--the temperature at which the ash becomes fluid and spreads out over the plaque in a flat layer.

The ranges in temperature between these points have been defined as follows:

a) Softening Interval--the range in temperature between the initial deformation and softening temperature;

b) Fluid Interval--the range in temperature between the softening and fluid temperatures; and

c) Melting range--the range in temperature between the initial deformation and fluid temperatures.

Selvig and Fieldner (II) have arbitrarily sub-divided the range of ash softening temperatures into three groups, as follows:

Class 1; Refractory ashes, softening above 2600°F.;

Class 2: Ashes of medium fusibility, softening between 2200 and 2600°F.; and

Class 3: Easily fusible ashes, softening below 2200°F.

The relationship of ash fusibility to clinker formation has been studied for many years, and it is conceded that the tendency to form clinker is not definitely related to the softening temperature of the ash. The present status of the problem has been stated by Nicholls and Selvig (12) in discussing the results of their work. They conclude that "no simple measure of the nature of the ash, such as its fusibility determined by an arbitrary method, can be expected to predict closely, relative values of troubles resulting from a complex ash passing through a set of conditions in which the temperature, time of exposure to that temperature, and travel of the ash are undefined, uncertain and dependent on factors that are also variable." Recent investigations conducted at the Fuel Research Laboratories (13) corroborate the above general statement.

Chemical Analysis of the Ash

The mineral matter in coal is composed mainly of compounds of silica, alumina, lime and iron, with smaller quantities of magnesia, titanium, phosphorus and alkali compounds. According to Thiessen et al (14), "the minerals comprizing the inorganic matter in coals are pyrite, calcite, kaolinite, detrital clay and silica".

Chemical analyses of the ash, however, show only the simple constituents present without indicating the manner in which they exist in the coal as minerals. In such analyses, the following compounds are usually determined and reported: SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, P_2O_5, and SO_3. These analyses, which were conducted in the chemical laboratory of the Division of Metallic Minerals of the Bureau of Mines, were made with certain modifications according to the methods outlined in the Third Edition of "Methods of The Chemists of The United States Steel Corporation For The Sampling And Analysis of Coal, Coke and By-products" published by Carnegie Steel Company, Pittsburgh, Pennsylvania, and in "Methods for The Quantitative Analysis of Coal Ash"--Physical and Chemical Survey of the National Coal Resources No. 28, Department of Scientific and Industrial Research, England.

Sulphur Forms

The sulphur in coal occurs in two principal forms, depending upon its origin, these being termed inorganic and organic.

The inorganic sulphur appears in two forms known as sulphate sulphur and puritic sulphur. The organic sulphur is composed of resinic and humic sulphur which, for all practical purposes, may be considered as total organic sulphur. Powell's (15) methods for determining quantitatively these sulphur forms were employed, with slight modifications, for these determinations.

Sulphate sulphur was determined by treating the pulverized coal with 3 per cent hydrochloric acid for 40 hours at 60°C., and estimating the sulphur in the filtrate by precipitation with $BaCl_2$.

Pyritic sulphur was determined by digesting the pulverized coal with 1.12 sp. gr. nitric acid for 96 hours at room temperature, the oxidized pyrite plus the original sulphate being determined by precipitation with barium chloride, the pyritic sulphur being calculated by subtracting the percentage of sulphur from the total inorganic sulphur.

Organic sulphur was estimated by subtracting the total inorganic sulphur from the total sulphur.

Information with respect to the distribution of the forms of sulphur is useful, inasmuch as it indicates the degree to which the sulphur content of a coal may be reduced by washing processes.

Fusain

The importance of fusain with respect to its influence on the spontaneous combustion of coal, and its effect on the coking properties, necessitates a study of its quantitative distribution between the various coal sizes. The method adopted with certain modifications for this determination was that of Heathcoat (16). This method takes advantage of the fact that, in bituminous coals, fusain is more resistant to oxidation than the other coal constituents. Hence, after oxidizing the insoluble humic material to an alkali-soluble humic substance, the more resistant fusain is collected by filtration, dried and ignited, and reported as "per cent dry ash-free fusain in dry ash-free coal".

A great deal of information with respect to coal washing may be obtained by studying the distribution of fusain in conjunction with the distribution of the forms of sulphur. Inasmuch as fusain is usually very porous in structure, it is often loaded with pyrite, and by reason of its friable nature it is usually concentrated in the fine coal dust. Elimination of fusain loaded with pyrite, by screening may result in a far greater reduction in the total sulphur content of the coal than would be obtained by a washing process.

The influence of fusain on coke structure is well known. Mott and Wheeler (17) have shown that the addition of this constituent in moderate amounts (usually about three per cent) to by-product oven charges of good coking coals permits the production of a 'blockier' and stronger coke of larger size. For coals with poor caking strength, however, the addition of fusain results in a weaker and sootier coke, and its removal from the charge is usually considered to be beneficial.

The influence of fusain on spontaneous combustion of stored coals is rather uncertain. Experiments by Stopes and Wheeler (18) led them to consider it improbable that fusain had a preponderating influence in promoting the actual ignition of the coal after self-heating had begun. They, however, considered it possible that "the rapid absorption of oxygen by fusain at low temperatures might be attended by a sufficient evolution of heat to raise appreciably the temperature of the main mass of the coal, thereby causing the most inflammable ingredient, vitrain, to react more rapidly with oxygen".

Classification of Coal By Rank

A committee of the American Society for Testing Materials (A.S.T.M.) has been studying various methods of coal classification for a number of years and has recently published standard specifications* for classification of coal both by rank and by grade. Prior to this, the Fuel Research Laboratories of the Canadian Bureau of Mines employed the 'specific volatile index'(19) method of coal classification, and as this method serves to classify coals for specific purposes, the two methods have been used for the coals reported herewith.

A.S.T.M. Classification by Rank (Designation D 388-38)

This method classifies coals by rank according to their fixed carbon and calorific values calculated to the mineral-matter-free basis. The higher rank coals are classified by fixed carbon on the dry basis, whereas the lower rank coals are classified by the B.t.u. per pound value on the moist basis. Agglomerating and weathering properties are used to differentiate between certain adjacent groups.

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* See A.S.T.M. Designations D-388-38 and D 389-38 in reference (6), also "Report on the A.S.T.M. Standard Specifications For Classification of Coals by Rank and by Grade and Their Application to Canadian Coals" N.R.C. No. 814--National Research Council of Canada.

A.S.T.M. Classification By Rank - As per Designation D 388-38

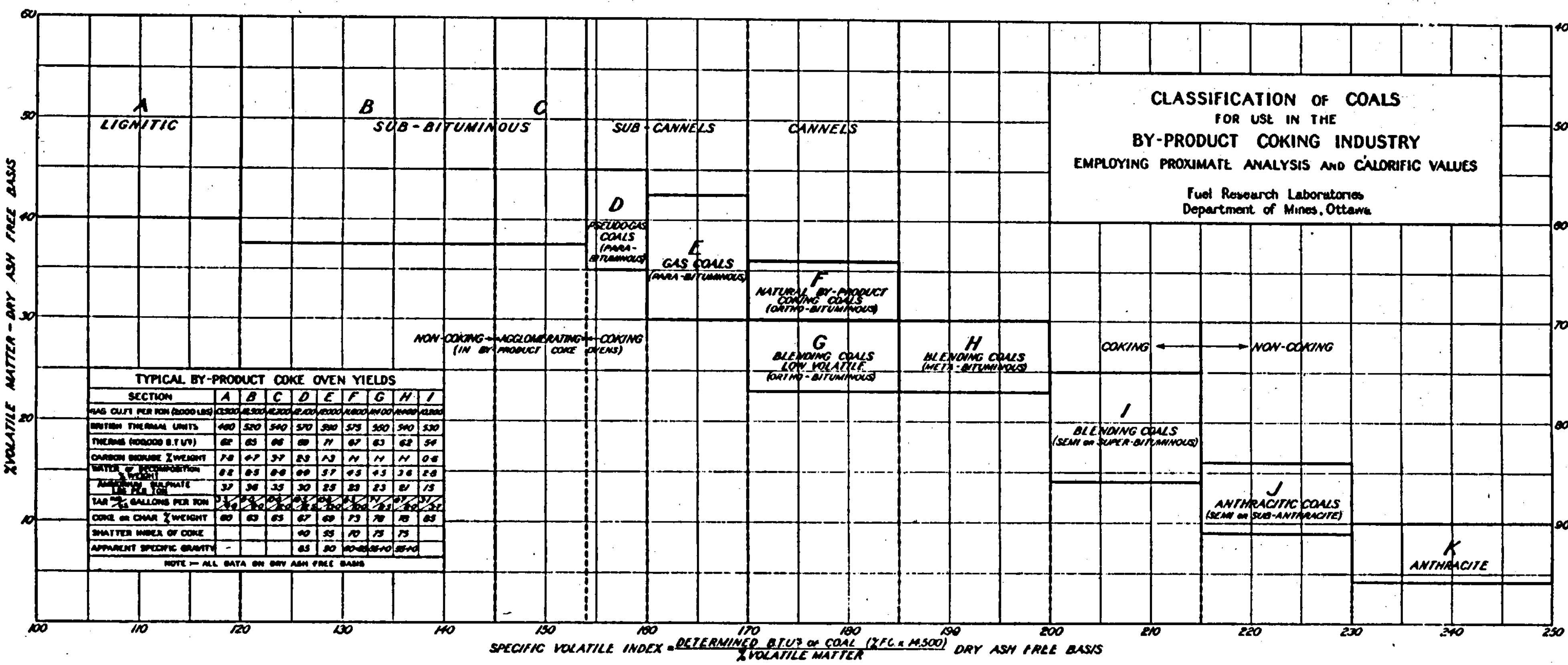
Classes and Groups	Limits of Fixed Carbon (F.C.) and B.t.u.(mineral-matter-free basis) and Requisite Physical Properties
I. Anthracitic class	
1. Meta-anthracite....	Dry F.C., 98 per cent or more.
2. Anthracite.........	Dry F.C., 98 to 92 per cent.
3. Semi-anthracite....	Dry F.C., 92 to 86 per cent, non-agglomerating.
II. Bituminous class	
1. Low volatile.......	Dry F.C., 86 to 78 per cent.
2. Medium volatile....	Dry F.C., 78 to 69 per cent.
3. High volatile A....	Dry F.C., less than 69 per cent and moist B.t.u. 14,000 or more.
4. High volatile B....	Moist B.t.u., 14,000 to 13,000.
5. High volatile C....	Moist B.t.u., 13,000 to 11,000, either agglomerating or non-weathering.
III. Subbituminous class	
1. Subbituminous A....	Moist B.t.u., 13,000 to 11,000, both weathering and non-agglomerating.
2. Subbituminous B....	Moist B.t.u., 11,000 to 9,500.
3. Subbituminous C....	Moist B.t.u., 9,500 to 8,300.
IV. Lignitic class	
1. Lignite...........	Moist B.t.u., less than 8,300 (consolidated)
2. Brown coal.........	Moist B.t.u., less than 8,300 (unconsolidated)

Specific Volatile Index (S.V.I.) Classification

This method is based on the heating value of the volatile matter, the values or indices obtained arranging coals in increasing value from peats to anthracites according to their rank. The index is calculated according to the following formula:-

$$\frac{\text{Determined B.t.u.} - (14{,}500 \times \text{weight of fixed carbon})}{\text{Per cent of volatile matter}} = \text{S.V.I.}$$

For ordinary purposes, the index is calculated on the dry, or dry ash-free, basis, but when the ash content is over 10 per cent and the sulphur over 1.5 per cent the calculation is made on the 'unit coal basis' (A.S.T.M. Designation D 388-38T.



TYPICAL BY-PRODUCT COKE OVEN YIELDS

SECTION	A	B	C	D	E	F	G	H	I
GAS CU.FT PER TON (2000 LBS)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BRITISH THERMAL UNITS	460	520	540	570	590	575	560	540	530
THERMS (100,000 B.T.U'S)	62	65	66	69	71	67	63	62	54
CARBON DIOXIDE % WEIGHT	7·8	4·7	3·7	2·3	1·3	1·1	1·1	1·1	0·6
WATER of DECOMPOSITION % WEIGHT	8·2	8·5	8·6	6·9	5·7	4·5	4·5	3·6	2·8
AMMONIUM SULPHATE LBS PER TON	37	36	35	30	25	23	23	21	15
TAR %/% GALLONS PER TON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
COKE or CHAR % WEIGHT	60	63	65	67	69	73	78	78	85
SHATTER INDEX OF COKE				40	55	70	75	75	
APPARENT SPECIFIC GRAVITY	-			85	90	90-95	95-1·0	95-1·0	

NOTE :— ALL DATA ON DRY ASH FREE BASIS

Chart I

In accordance with this classification, coals are arbitrarily divided into the following groups.

	'Unit Coal' S.V.I. Limits	Volatile Matter Range Per Cent.
Brown lignites...	82 - 99	40 - 70
Black lignites...	99 - 125	36 - 55
Sub-bituminous...	125 - 160	35 - 50
Para-bituminous..	160 - 175	28 - 45
Ortho-bituminous.	175 - 190	21 - 35
Meta-bituminous..	190 - 210	21 - 28
Semi-bituminous..	210 - 230	14 - 24
Semi-anthracite..	230 - 255	9 - 16
Anthracites......	255 - 300	3 - 10

By noting the position of a coal on a chart, as per Chart I, according to its S.V.I. and volatile matter, it is possible to predict with a fair degree of accuracy the characteristics of the coal with respect to its behaviour in a by-products coke oven and the approximate yield of by-product to be expected. These characteristics are indicated in the table inserted in the lower left hand corner of Chart I, in which, it is to be noted, the data are on the dry ash-free basis.

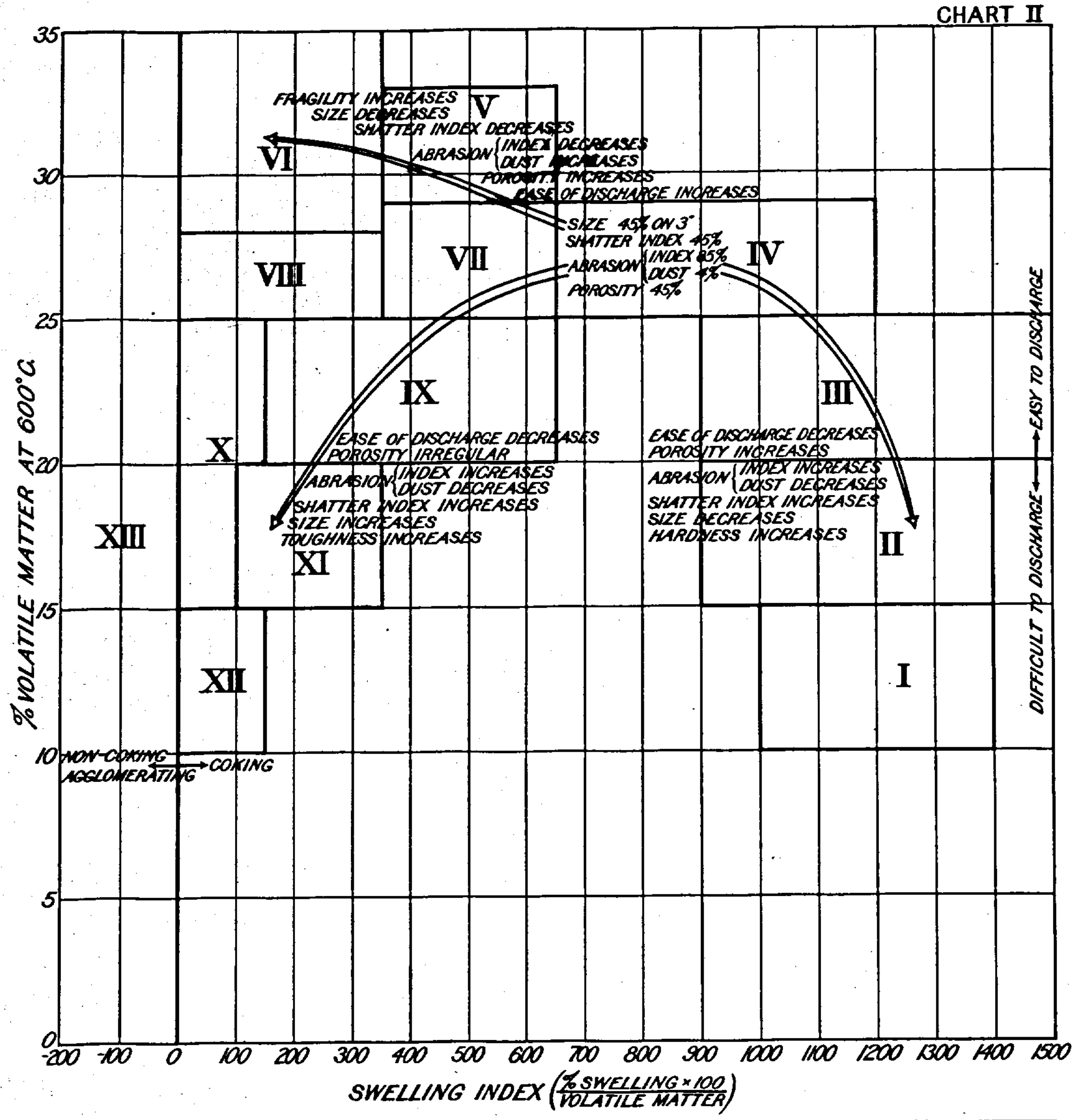
Coking Properties

Swelling Index Test

In order to predict the physical properties of the (by-product) coke made from any given coal, a laboratory test was developed at the Fuel Research Laboratories of the Canadian Bureau of Mines and was published by the Mines Branch(20). This test consists of determining the volatile matter and the percentage swelling of the coke button at a temperature of 600°C. From these data, the swelling index is caluulated and, by the aid of a coke classification chart, shown as Chart II, the coal is located in a particular group. The various groups are arbitrarily delimited according to the known physical properties of the cokes made from coals in these groups.

In addition to the use of this test for the by-product coke industry, its value is indicated in other fields. From a paper given at the A.I.M.E. meeting in 1937 by H.F. Hebley, viz: "Economics of Preparing Coal For Steam Generation" and reviewed in the Iron and Coal Trades Review (February 11, 1938, p. 277), the author may be quoted in parts as follows:- "With coal of a highly-coking nature, the swelling characteristics often have a great influence on the ability of a stoker to maintain its load ....When the use of underfeed stokers is considered, the

CHART II



SECTION	ASH %	SIZE ON WHARF		SHATTER		ABRASION		DENSITY		TRANSVERSE SHRINKAGE	APPEARANCE OF NATURAL SURFACE	SHAPE	STRENGTH	CROSS FRACTURE	LONGITUDINAL FRACTURE	CELL STRUCTURE	SPONGE	PEBBLY SEAM
		% ON 3"	BREEZE	INDEX	BREEZE	INDEX	DUST	APP. S.G.	LB. C.F.									
I		POCAHONTAS TYPE BLENDING COALS								NIL			HARD				VERY LITTLE	NONE
II		25-40	2·5-1·0	85-55	3·0-2·0	85-95	3·5-2·0	·85-·95	24-26	FAIR*	STEEL GREY AND SMOOTH	SQUARE	HARD	MEDIUM TO LARGE AMOUNT STRAIGHT	SMALL TO MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
III		30-45	2·5-1·0	50-65	3·0-2·0	85-95	3·5-2·0	·90-1·0	25-28	FAIR TO GOOD	STEEL GREY AND SMOOTH	SQUARE	HARD	MEDIUM AMOUNT, SQUARE	SMALL TO MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
IV		40-50	3·0-2·0	45-55	3·0-2·0	80-90	5·0-3·0	1·0-1·1	26-29	GOOD	STEEL GREY, FAIRLY SMOOTH	SLIGHTLY TRIANGULAR	HARD	MEDIUM AMOUNT, STEPPY	MEDIUM AMOUNT	DENSE	VERY LITTLE	NONE
V		30-50	4·0-2·0	40-50	6·0-4·0	75-85	5·0-3·0	1·0-0·9	26-29	GOOD	STEEL GREY, IRREGULAR	TRIANGULAR FINGERY	FRAGILE	MEDIUM TO LARGE AMOUNT STEPPY	MEDIUM TO LARGE AMOUNT	MEDIUM	SMALL TO MEDIUM AMOUNT	NONE
VI		30-50	2·0-5·0	25-40	6·0-4·0	55-80	7·0-3·0	·85-0·9	25	VERY GOOD	STEEL GREY, IRREGULAR	TRIANGULAR VERY FINGERY	VERY FRAGILE	MEDIUM TO LARGE AMOUNT STEPPY	LARGE AMOUNT	MEDIUM TO LARGE	MEDIUM AMOUNT	NONE
VII	0-5	40-50	4·0	55-70	3·0	80-95	2·5-5·0	·83	23·5	GOOD	STEEL GREY, IRREGULAR	BLOCKY; SLIGHTLY TRIANGULAR	HARD TO FRAGILE	SMALL TO MEDIUM, SLIGHTLY STEPPY	MEDIUM TO SMALL AMOUNT	MEDIUM TO SMALL	SMALL AMOUNT	NONE
	5-10	50-70	4·0	55-70	3·0	80-95	2·5-5·0	·83-·95	23·5-26	"	"	"	"	"	"	"	"	"
	10-15	70-50	5·0	55-70	3·0	80-95	2·5-5·0	·95	26	"	"	"	"	"	"	"	"	"
VIII		50-70	2·0-5·0	45-65	4·0-5·0	60-80	2·5-7·0	·85-·95	24-26	GOOD	STEEL GREY, IRREGULAR	SLIGHTLY TRIANGULAR AND FINGERY	HARD TO FRAGILE; FRIABLE	MEDIUM AMOUNT; SLIGHTLY STEPPY	MEDIUM AMOUNT	MEDIUM; IRREGULAR	SMALL AMOUNT	NONE
IX	0-5	45-55	4·0	70	3·0	93	2·5	·80-·86	22-25	GOOD	STEEL GREY, SLIGHTLY IRREGULAR	BLOCKY, SLIGHTLY TRIANGULAR	TOUGH TO HARD	SMALL TO MEDIUM; SLIGHTLY STEPPY	SMALL TO MEDIUM AMOUNT	SMALL TO MEDIUM	SMALL AMOUNT	NONE
	5-10	55-80	2·0	70-80	3·0-5·0	90	2·5	·86-1·1	25-31·5		"	"	"	"	"	"	"	"
	10-15	80-55	2·0-4·0	70-80	3·0-5·0	90	2·5	1·1-·92	31·5-25		"	"	"	"	"	"	"	"
X		70-80	3·0-5·0	65-80	10·0-5·0	70-80	10·0-7·0	·95-1·1	26-30	FAIR TO GOOD	DULL; GRANULAR	BLOCKY; IRREGULAR	TOUGH; FRIABLE	SMALL AMOUNT, SLIGHTLY STEPPY	SMALL AMOUNT	SMALL TO MEDIUM	GRANULAR ENDS	PEBBLY
XI		70-80	3·0	70-80	5·0	85-90	3·0-4·0	1·0-1·1	30-31	FAIR	DULL TO STEEL GREY; IRREGULAR	BLOCKY; SQUARE	TOUGH	SMALL AMOUNT; VERY SLIGHTLY STEPPY	SMALL AMOUNT	IRREGULAR	VERY LITTLE	NONE
XII		80	3·0	80	5·0	85	4·0	1·0-1·1	30-31	FAIR TO POOR	DULL GREY, IRREGULAR	BLOCKY; IRREGULAR	TOUGH; FRIABLE	VERY SMALL AMOUNT; IRREGULAR	VERY LITTLE	IRREGULAR	VERY LITTLE	NONE
XIII		25-70	4·0-3·0	30-70	20·0-5·0	50-80	15·0-5·0	·85-1·1	23·5-28	GOOD	DULL GREY, GRANULAR	BLOCKY, IRREGULAR	FRIABLE	SMALL TO MED. AMOUNT; IRREGULAR	SMALL TO MEDIUM AMOUNT	VERY LITTLE TO NONE	GRANULAR ENDS	PEBBLY TO NON COKING

*DIFFICULT TO DISCHARGE

Chart 2. Classification for By-product Cokes according to their physical properties, employing Volatile Matter and "Swelling Index" at 600° C. of the coal.

rate of combustion has a pronounced effect on the character of the coke produced during the operation of the stoker....Some coals form hard dense coke masses, which fracture and break up much less readily than others. Other coals contract somewhat after initial coking, thereby causing fissures through the coke masses." It is obvious, therefore, that the evaluation of this swelling and coking property is very important in determining the suitability of coals for stoker use as well as for coke manufacture.

Caking Index

It has been shown that those coals which are recognized as falling within the best coke-producing class are more capable of withstanding a higher mixture of inert material and still yield a carbonized residue of definite crushing strength than are the inferior coals. This phenomenon of 'caking' or 'agglutination' has been thoroughly studied, and methods have been developed for the determination of the caking index. While these tests are of uncertain value for the purpose of assessing a wide range of coals in their application to the production of by-product coke, a knowledge of the caking index is of importance when it is desired to mix inert carbonaceous material, or non-coking coal, with coking coals.

The method developed by Gray(21), in which 25-gramme mixtures of coal and sand in varying proportion are carbonized in crucibles at 950°C., has been adopted as a standard at the Fuel Research Laboratories. The ratio of sand to coal, which on carbonization will form a sufficiently strong button to support a weight of 500 grammes, is designated as the 'caking index'. The higher the caking index, the greater the caking properties.

According to Malleis(22), the agglutinating value test has generally been found to have value for special investigation such as detecting deterioration of coking properties of coal due to storage, but it seems to have little value as a reliable index of the probable caking or coking properties of a coal.

Laboratory Washing Tests

Coal washing, generally speaking, depends on the difference in the specific gravities of the coal and refuse, and this difference has been used in the laboratory for many years by means of float-and-sink tests, to differentiate betwedn these materials. By the successive separation of a coal at various gravities, washability curves may be constructed which will indicate for any given coal the theoretical ash content and yield of both clean coal and refuse obtainable at any chosen gravity.

The data obtained from such tests on 1½ inch slack, the details of which are shown in a series of tables in Chapter IV, were plotted according to the method outlined by Campbell(23) of the American Rheolaveur Coroporation. To these was added the 'specific gravity distribution' curve as suggested by Bird(24) of the Battelle Memorial Institute. The curves, as constructed, contain the following information:

Curve 1, the cumulative float ash per cent curve, represents the variation of the ash.

Curve 2, the variation in ash per cent of the material with variation in gravity at which the separation is made.

Curve 3, the cumulative sink per cent according to the recovery as in Curve 1.

Curve 4, the variation in recovery according to the specific gravity.

Curve 5, the ± .10 specific gravity distribution curve, represents a measure of the comparative difficulty of separation according to specific gravity at the selected point of separation.

According to Bird, the degree of difficulty of wet washing a coal may be predicted from the specific gravity distribution curve, and its application to standard processes is summarized in the following table.

±.10 Curve Per cent	Degree of Difficulty	Preparation
0 - 7	Simple...............	Almost any process; high tonnage
7 - 10	Moderately difficult.	Efficient process; high tonnage
10 - 15	Difficult............	Efficient process; medium tonnage
15 - 20	Very difficult.......	Efficient process; low tonnage
20 - 25	Exceedingly difficult	Very efficient process; low tonnage
Above 25	Formidable...........	Limited to a few exceptionally efficient processes

For the study of an ordinary bituminous coal, 10 per cent on the curve is used, and the specific gravity representing this point is usually selected for the wasing of a composite sample, the clean coal and refuse fractions of which are studied for their various properties. If a horizontal line is drawn from this point on Curve 4 (specific gravity curve), the points at which it cuts the other lines represent the following:

Curve 1, the average ash per cent of the separated coal;

Curve 2, the actual ash per cent of the heaviest piece of material left in the coal, and likewise the lightest piece of material in the refuse; and

Curve 3, the average ash per cent of the refuse extracted.

REFERENCE CITED

(1) Bennett, J.C.: "Broken Coal" - The Institute of Fuel, Vol. X, No. 49, pp. 22-29, 1936.

(2) Smith, C.M.: "An Investigation of the Friability of Different Coals" - University of Illinois Bulletin No. 196, 1929.

(3) Burrough, E.J., Strong, R.A., and Swartzman, E.: "Method Now in Use at the Fuel Research Laboratories for Determination of Apparent Specific Gravity of Coke" - R.I.C.S. 35, 1934 (not published)

(4) Rosin, P.O.: "Influence of Particle Size in Processes of Fuel Technology" - The Institute of Fuel, Vol. XI, No. 55, pp. 26-41, 1937.

(5) Gilmore, R.E., Nicolls, J.H.H., and Connell, G.P.: "Coal Friability Tests" - Canadian Bureau of Mines Bulletin No. 762, - 1935.

(6) A.S.T.M. Standards on Coal and Coke - Prepared by Committee D-5 on Coal and Coke, October 1938. Published by American Society for Testing Materials. Philadelphia, Pa.

(7) von Rittinger, P.K.: "Lehrbuch der Aufberichtungskunde" Berlin, 1867.

(8) Fuel Economist, Vol. 11, No. 132, p. 454, September 1936.

(9) Bone, W.A.: "Coal and Its Scientific Uses" - Longmans Green & Company, London, 1918.

(10) Grumell, E.S.: "The Evaluation of Coal, with Particular Reference to Small Coal for Steam Raising" - Institute of Fuel, Vol. VIII, No. 40, pp. 220-224.

(11) Selvig, W.A., and Fieldner, A.C.: "Fusibility of Ash From Coals of the United States" - U.S. Bureau of Mines Bulletin 209, 1932.

(12) Nicholls, P., and Selvig, W.A.: "Clinker Formation as Related to the Fusibility of Coal Ash" - U.S. Bureau of Mines Bulletin 364, 1932.

(13) Strong, R.A., Swartzman, E., and Burrough, E.J.: "Laboratory Study of the Effect on the Fusibility of the Ash of Blending Emery Seam Coal With Coals from the Harbour and Phalen Seams" - R.I.C.S. 82, Fuel Research Laboratories, Canadian Bureau of Mines.

(14) Thiessen, G., Ball, C.G., and Grotts, P.E.: "Coal Ash and Coal Mineral Matter" - Industrial and Engineering Chemistry, Vol. 28, No. 3, pp. 355-361, 1936.

(15) Powell, A.R.: "The Analysis of Sulphur Forms in Coal" - U.S. Bureau of Mines Technical Paper 254, 1921.

(16) Heathcoat, F.: "The Estimation of Fusain" - Fuel in Science and Practice, October 1930, p. 452.

(17) Mott, R.A., and Wheeler, R.V.: "Cokes for Blast Furnaces" The Colliery Guardian Company, Limited, London, 1930.

(18) Stopes, M.C., and Wheeler, R.V.: "The Spontaneous Combustion of Coal" - Fuel in Science and Practice, Vol. II, No. 4, 1923.

(19) Burrough, E.J., Swartzman, E., and Strong, R.A.: "Classification of Coals Using Specific Volatile Index" - Canadian Bureau of Mines Publication No. 725-2, 1933.

(20) Strong, R.A., Burrough, E.J., and Swartzman, E.: "A Laboratory Test on Coals for Predicting The Physical Properties of the Resultant By-product Coke" - Mines Branch Publication No. 737-2.

(21) Gray, Thomas: "The Determination of the Caking Power of Coal" - Fuel in Science and Practice, Vol. 2, p. 42, 1923.

(22) Malleis, O.O.: "Laboratory Tests Relating to Caking, Plastic, Gas - and Coke-making Properties of Bituminous Coals" - A.S.T.M. Symposium on Significance of Tests of Coal - Proceedings of A.S.T.M., Vol.37, 1937.

(23) Campbell, J.R.: "Cleaning Bituminous Coal" - Proceedings of the 1928 World Power Conference held in the U.S.A.

(24) Bird, B.M.: "Interpretation of Float and Sink Data" - Proceedings of the Second International Conference on Bituminous Coal, 1928, pp. 82-111.