CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY

OTTAWA

ENERGY RESEARCH LABORATORIES
DIVISIONAL REPORT ERL 75/38-CMFRL

EVALUATION OF THE COKING CHARACTERISTICS OF A COAL SAMPLE FROM SEAM 7, (ADIT 88) EAST KOOTENAY AREA, BRITISH COLUMBIA, SUBMITTED BY KAISER RESOURCES LTD.

Project 03-3-1/16-30

by

J.G. Jorgensen, W. Gardiner, T.A. Lloyd and J.C. Botham

March, 1975

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INTRODUCTION

Since 1959, the Mines Branch of the Department of Energy, Mines and Resources (EMR) has carried out periodic investigations to assist in the development of the coking coals of Western Canada with a view to their eventual exploitation as metallurgical coals, principally in the steel industry.

These studies have also included departmental representation on several coal missions to Japan to discuss specific technical aspects regarding the use of Canadian coals in that country. During the initial visit in 1958, general discussions were held in Tokyo with representatives of the Japanese steel industry, and it was agreed that continuing test work by EMR in Canada would be of mutual benefit in helping to maintain the flow of good quality coking coal to the growing market in Japan. A subsequent visit in 1973 confirmed the need for these studies.

Many carbonization investigations have been completed in the laboratories of the Mines Branch for coal companies involved in the export market, and this

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work has assisted the companies concerned to obtain firm export contracts. The resulting investigational reports are, in most cases, confidential and are usually restricted to the principals of the company.

The present investigation deals with an evaluation of the coking characteristics of a coal sample from Adit No. 88, Seam No. 7, East Kootenay area, British Columbia, submitted by Kaiser Resources Limited (KRL).

The project was initiated in a letter dated 28th January 1975, from Mr. D.P. Sharma of KRL to Mr. J.C. Botham (CANMET). This letter is included as Appendix 1, in this report.

The data presented herein consist of chemical analysis, petrography, bench-scale testing pertinent to cokemaking, and a technical scale coke oven evaluation of the sample.

The sample was carbonized alone in the 12-inch movable-wall oven in Ottawa, and the coke product evaluated for its physical properties.

FIGURE 1

General Project Flowsheet

(Project No. 03-3-1/16-30)

COALS FOR PROJECT

Seam 7, Adit 88

GENERAL PREPARATION

- Air Dry
- Screen
- Crush Oversize
- Blend to 80% - 1/8"
- Split Head Sample to Lab.
- Re-Drum & Store for Future Blending as Required

CARBONIZATION

- Weigh out Blend Components Allowing for Moisture Contents
- Blend in V. Shell Blender
- Air Dry to 48.5 lb/ft^3 ASTM Cone Method
- Charge Mines Branch MW Coke Oven
- Retain Sample of Charge for Lab.
- Standard Procedures for Coke Oven Operation

COKE EVALUATION

- Screen Analysis
- Select Coke for ASTM Tumbler JIS Drum Test
- Apparent Specific Gravity
- Oven Wall Pressures

LABORATORY WORK

	Head	Blend
. Petrography	x	
. Moisture	x	
. Proximate	x	
. Sulphur	x	
. Btu/lb (dmmf)	x	
. Screen Tests	x	
. Ultimate	x	
. Ash Analysis	x	
. Plasticity	x	
. FSI	x	
. SVI Calculation	x	
. Dilatation	x	
. Grindability	x	
. Expansion/Contraction	x	
. Ash Fusibility	x	

Analytical Program

Representative coal samples from the gross sample submitted were analysed as follows:

A. Chemical and Related Analysis- (reported in Table 1)

(a) Proximate Analysis
(1) Moisture
(2) Ash
(3) Volatile Matter
(4) Fixed Carbon

(b) Ultimate Analysis
(1) Carbon
(2) Hydrogen
(3) Sulphur
(4) Nitrogen
(5) Oxygen (by difference)

(c) Gross Calorific Value

(d) Ash Analysis
(1) Silicon Dioxide
(2) Aluminum Oxide
(3) Ferric Oxide
(4) Titanium Oxide
(5) Phosphorus Oxide
(6) Calcium Oxide
(7) Magnesium Oxide
(8) Sulphur Trioxide
(9) Sodium Oxide
(10) Potassium Oxide

B. Physical Tests (reported in Table 2)

(a) Hardgrove Grindability
(b) Size Consist of Oven Charge
(c) Ash Fusibility

Representative samples of coke oven coal charges and resultant cokes were taken for proximate analysis and sulphur determination. These values are listed in Table 6.

C. Thermal Rheological Properties (reported in Table 3)

(a) Gieseler Plasticity
(b) Ruhr Dilatation
(c) Free Swelling Index
(d) Linear Expansion

D. Petrography (reported in Table 4)

(1) Microscopic Determination of Volume Per cent of Maceral Components

(2) Microscopic Determination of Reflectance Values of Organic Components
(3) Mathematical Determination of Potential Coke Stability

CARBONIZATION

Technical-scale evaluations of the coals and coal blends were carried out in the Mines Branch movable-wall test oven. This type of oven is presently under consideration for adoption as a standard test method, by Sub-Committee XV of ASTM Committee D-5 as "Proposed Method of Test for Measuring Coking Pressures of Coal by a Movable-wall Slot Oven". The Mines Branch test oven is identical with the "Quality Coke Oven" as designed and used by the Eastern Gas and Fuel Association(1), differing from the latter unit in minor details only. A schematic drawing of the oven, showing the supporting steel and fire-brick construction is given in Figure 2.

The width of the coke-oven chamber is 12.5 inches and the oven capacity is approximately 500 lbs of dry coal at an oven bulk density of 51 lb/ft^3 (db). The coking chamber is equipped with two doors and the coke is discharged by means of a pusher machine.

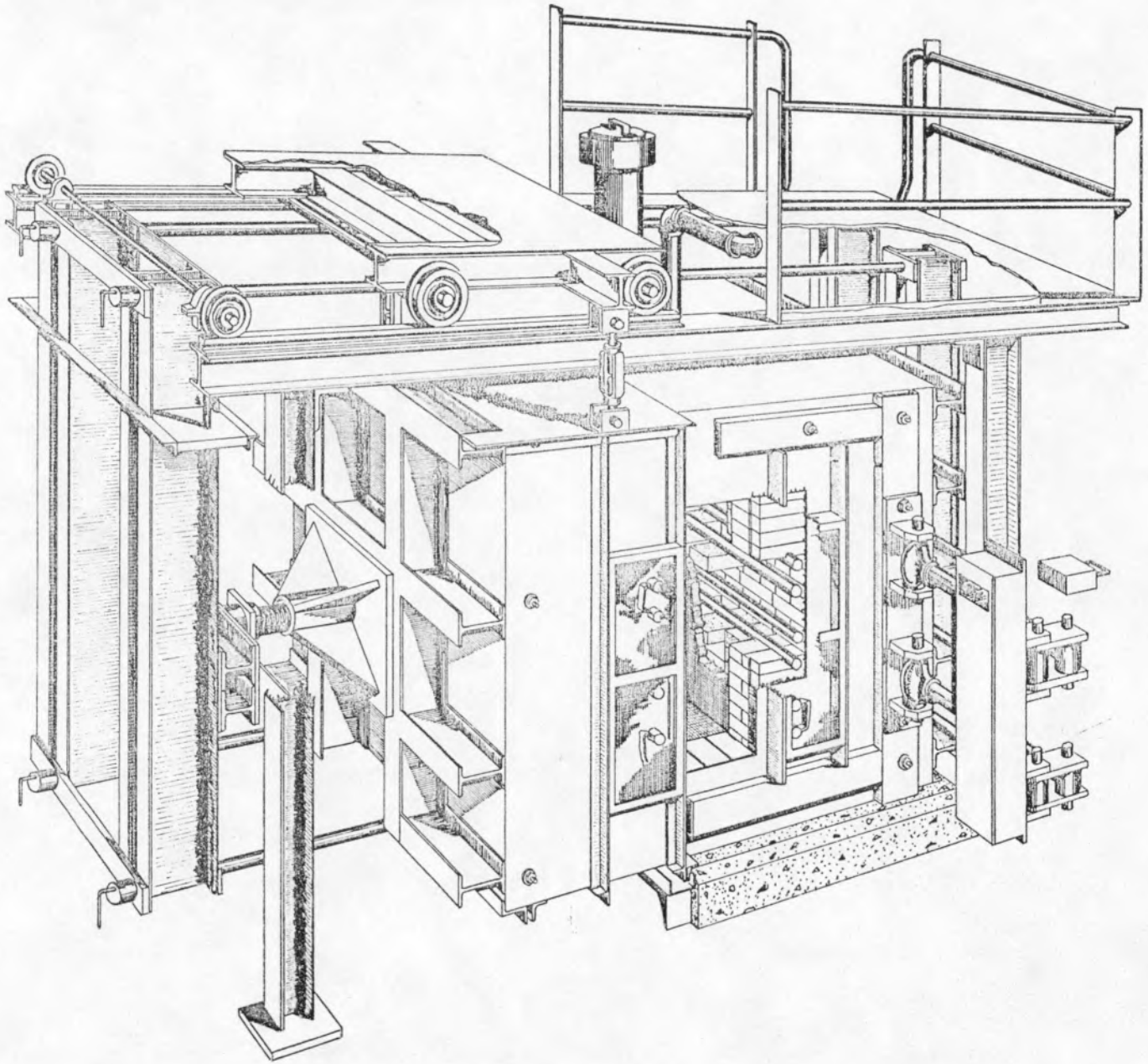
The oven is electrically heated with "Globar" -type resistance elements, provided with a sensitive control system to regulate and maintain desired oven-wall temperatures. The oven walls consist of silicon-carbide tile with a high thermal conductivity relative to silica brick. In order to simulate the conditions of heating in a commercial oven, energy input to the test oven is normally programmed. The coal is charged to the oven at a flue temperature of 1650°F. The temperature is then increased at a rate of 35°F/hr to 1950°F and maintained for balance of coking time at this temperature. The coke is pushed 1/2 hour after the temperature in its center has reached 1850°F.

This heating cycle simulates a commercial oven coking rate of 1 inch per hour as would be obtained in a conventional 18-inch silica lined coke oven. With such programming the slot-face temperatures average approximately 1850°F for the coking cycle.

The wall pressure developed by the coal charge during the test is measured by means of a single compression-type load cell. The movable-wall section of the test oven is suspended from an overhead carriage rolling on rails. Motion of the movable-wall is restrained by an assembly of heavy steel beams held against the fixed wall by four water-cooled tie rods. A single BLH load-cell, Type CXX, with a range of 0-10,000 pounds, is mounted between the movable-wall and the restraining structure. A Foxboro "Dynalog" electronic strain-gauge continuously records the force transmitted through the movable-wall during the test.

All cokes discharged from the oven are dropped from a height of 10 feet to simulate handling of the coke in commercial practice. The cokes are dried prior to screening and testing.

The chemical analysis and the coal and coke testing conform as closely as possible to ASTM test-methods. Standard test-method designations, other than chemical analysis, are given in the references.



Mines Branch Movable-Wall Coke Oven

FIGURE 2

TABLE 1 Chemical Analyses of Component Coals

Identification	
Laboratory Number	2556-75
Description	Seam 7 Adit 88
Classification	
Rank (ASTM)	lvb
International System	431
Specific Volatile Index	197
Carbon (dmmfb) %	90.7
Proximate Analysis (db)	
Ash %	9.4
Volatile Matter %	20.6
Fixed Carbon %	70.0
Gross Calorific Value (db)	
Btu per pound	14,020
Ultimate Analysis (db)	
Carbon %	81.3
Hydrogen %	5.1
Sulphur %	0.42
Nitrogen %	1.4
Ash %	9.4
Oxygen (by difference) %	2.4
Ash Analysis (db)	
SiO_2 %	*
Al_2O_3 %	
Fe_2O_3 %	
TiO_2 %	
P_2O_5 %	
CaO %	
MgO %	
SO_3 %	
Na_2O %	
K_2O %	

*Results not available at time of reporting.

TABLE 2 Physical Tests and Fusibility of Ash of Component Coals

Identification		
Laboratory Number		2556-75
Description		Seam 7 Adit 88
Coal Pulverization		
Sieve Analysis		
Passing	Retained On	
	1/4 in. %	1.4
1/4 in.	1/8 in. %	10.8
1/8 in.	1/16 in. %	22.4
1/16 in.	1/32 in. %	19.1
1/32 in.	.....%	46.3
Total Passing	1/8 in. %	87.8
Grindability		
Hardgrove Index		*
Fusibility of Ash		
Initial Deformation Temp. ...	°F	2700+
Softening Temp. Spherical ...	°F	2700+
Softening Temp. Hemispherical	°F	2700+
Fluid Temp.	°F	2700+

*Results not available at time of reporting.

TABLE 3 Thermal Rheological Properties of Component Coals

Identification	
Laboratory Number	2556-75
Description	Seam 7 Adit 88
Linear Expansion	
Bd. 52 lb/ft^3 at 2% moisture...%	-14.0
Gieseler Plasticity	
Start .....^{o}C	447
Fusion Temp. .....^{o}C	-
Max. Fluid Temp. .....^{o}C	464
Final Fluid Temp. .....^{o}C	477
Solidification Temp. .....^{o}C	485
Melting Range .....^{o}C	30
Max. Fluidity .....dd/m	2.3
Torque .....g.in.	40
Dilatation	
Ti - Softening Temp. .....^{o}C	405
Tii - Max. Contraction Temp. ^{o}C	470
Tiii - Max. Dilatation Temp. .^{o}C	-
Contraction .....%	24
Dilatation .....%	NIL (at 500^{o}C)
Free Swelling Index	
F.S.I.	4.5

TABLE 4 Petrographic Analysis of Component Coals

Identification	
Laboratory Number	2556-75
Description	Seam 7 Adit 88
Distribution of Vitrinite Types	
V-6....%	
V-7....%	
V-8....%	
V-9....%	
V-10....%	0.5
V-11....%	0.5
V-12....%	27.4
V-13....%	18.4
V-14....%	0.5
V-15....%	
V-16....%	
V-17....%	
V-18....%	
Reactive Components	
Total Vitrinite....%	47.3
Reactive Semi-fusinite (1/3)...%	13.6
Exinite....%	0.0
Total....%	60.9
Inert Components	
Inert Semi-fusinite (2/3)....%	27.1
Micrinite....%	2.8
Fusinite....%	3.9
Mineral Matter....%	5.3
Total....%	39.1
Petrographic Indices	
Mean Reflectance....%	1.28
Balance Index....	2.90
Strength Index....	4.94
Stability Index....	44.3

TABLE 5 - Carbonization Data - Mines Branch 12-Inch M.W. Oven

Test Identification Number	396
Data of Test	20 Feb. 75
Laboratory Number	
Description	Seam #7 Adit #88 100%

CARBONIZATION DATA

Net Weight of Charge (wet) lb	559.3
Moisture in Charge %	2.8
ASTM Bulk Density (wet) lb/ft^3	48.5
Oven Bulk Density (db) lb/ft^3	51.3

CARBONIZATION RESULTS

Gross Coking Time hr:min	9:05
Maximum Wall Pressure lb/in^2	0.56
Coke Yield Actual %	78.0
Mean Coke size in	2.11
Apparent Specific Gravity	

Screen Analysis of Coke
(cumulative percentage retained on)

3 inch sieve	14.5
2 inch sieve	50.4
1 1/2 inch sieve	74.4
1 inch sieve	91.4
3/4 inch sieve	94.2
1/2 inch sieve	94.9
Percentage -1/2 inch (breeze)	5.1

Tumbler Test (ASTM)

Stability Factor	49.9
Hardness Factor	69.1

Japanese Drum Test (JIS)
(cumulative percentage retained on)

	30 REV	150 REV
50 mm sieve	6.3	2.3
25 mm sieve	85.0	66.5
15 mm sieve	92.9	81.4

TABLE 6

Analyses of Coke Oven Charges and Resultant Cokes

Identification	
Test Number.....	396
Date Charged.....	20 Feb. 75
Description.....	Seam 7 Adit 88
Coke Oven Charge	
Laboratory Number.....	2556-75
Proximate Analysis (db)	
Ash.....%	9.4
Volatile Matter.....%	20.6
Fixed Carbon .....%	70.0
Sulphur (db).....%	0.42
Resultant Coke	
Laboratory Number.....	2612-75
Proximate Analysis (db)	
Ash.....%	*
Volatile Matter.....%	
Fixed Carbon.....%	
Sulphur (db).....%	

*Results not available at time of reporting.

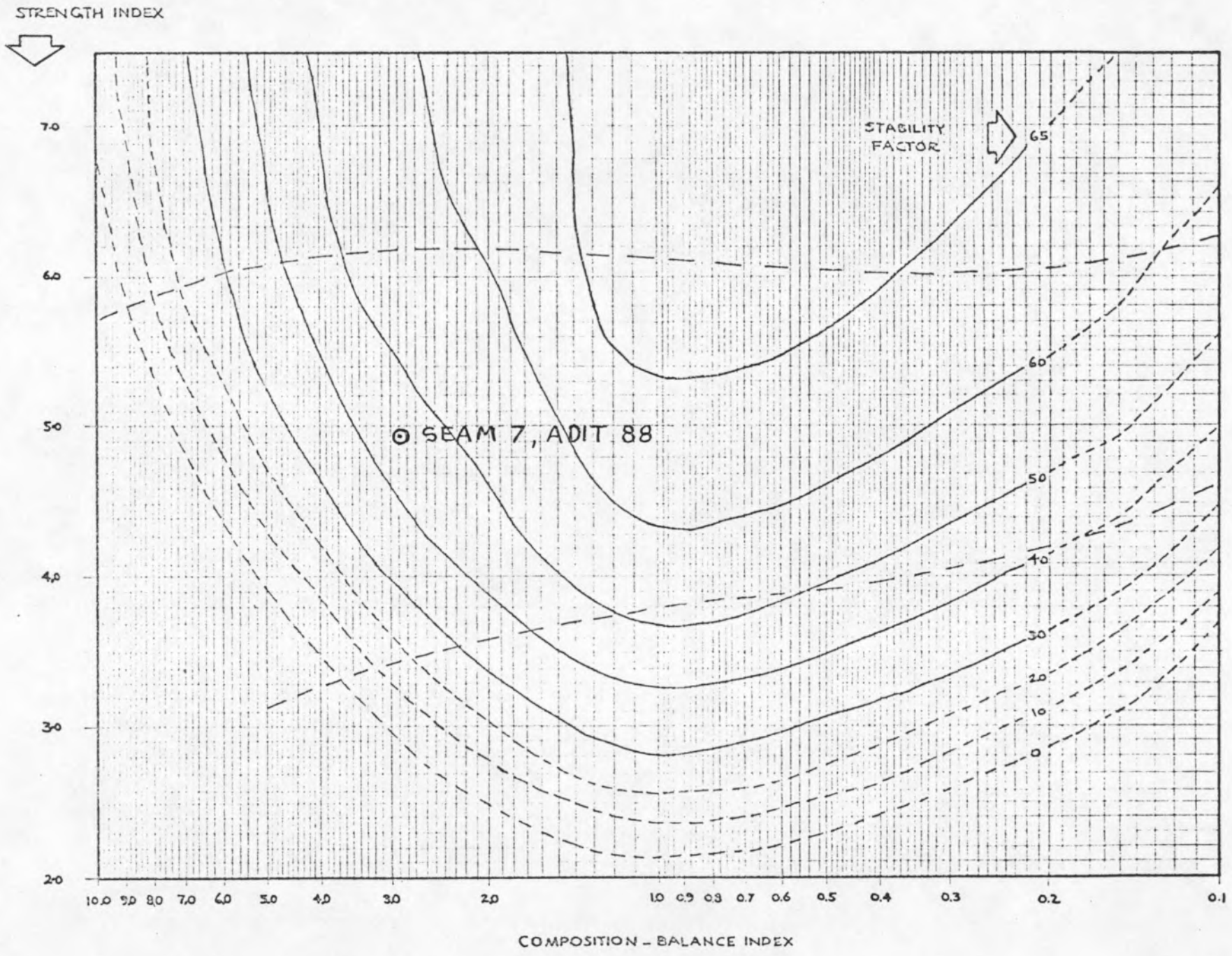


FIGURE 3: Potential Stability Factor of Component Coal

PROJECT OBSERVATIONS AND DISCUSSIONS

Rank

Based on the ASTM system of rank classification the coal sample from Seam 7, Adit 88 is low volatile bituminous coal.

Sulphur

The sulphur value is favourably low at 0.42 per cent.

Ash Level

The ash level is 9.4 per cent.

Thermal Rheological Properties

The Gieseler fluidity is 2.3 dial divisions per minute, the Ruhr dilatation is nil at 500^{o}C and the Free Swelling Index is 4.5. The Linear Expansion as determined by the Sole-heated oven is -14.0 per cent.

Petrography

The mean maximum reflectance value is 1.28 per cent which is typical of a medium volatile coal. The mean maximum reflectance of a coal is generally related to the degree of metamorphism or coalification that the coal has undergone and therefore is an indication of rank. However, based on the volatile matter and the fixed carbon this coal is ranked as low volatile bituminous. This anomaly appears to be due to the low vitrinite content and conversely the high inertinite content of this coal. The vitrinite and exinite contribute the bulk of the volatile matter and most of the inertinite remains in the fixed carbon.

The balance index is 2.90 which reflects excess of inert components. The predicted stability factor based on the petrographic analysis is 44.3.

Carbonization

The carbonization results compare fairly well with those associated with Balmer coal.

The Stability and Hardness factors, the JIS drum test and maximum pressure are the main parameters referred to in this assertion.

The breeze production at 5.1 per cent is a little high.

REFERENCES

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3. ASTM Designation: D720-67, "Test for Free Swelling Index of Coal".

4. ASTM Designation: D2639-71, "Test of Plastic Properties of Coal by the Constant-Torque Gieseler Plastometer." (Constant torque plastometer used with a torque of 40 gram-inch; start, 1 dd/m; fusion, 5 dd/m; final, 1 dd/m; solidification, no movement; range-temp., between start and final temperatures).

5. Burrough, E.J., "Specific Volatile Index", Fuels Division Memorandum 97/58-CG, Fuels and Mining Practice Division, Mines Branch, Dept. of M. and T.S., Ottawa, Canada (1958).

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7. ASTM "Proposed Method of Test for Measuring the Coking Pressures of Coals by a Movable-Wall Slot Oven" (presently under consideration for adoption as a standard method of test by Sub-Committee XV of ASTM Committee D-5).

8. ASTM Designation: D291-60, "Cubic Foot Weight of Crushed Bituminous Coal" Procedure A - Procedure for Uncompacted Cubic Foot Weight).

9. ASTM Designation: D293-69, "Test for Sieve Analysis of Coke".

10. ASTM Designation: D294-64, "Tumbler Test for Coke".

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12. Burrough, E.J., Strong, R.A. and Swartzman, E., "Report of Investigation on the Method Now in Use at the Fuel Research Laboratories for Determination of the Apparent Specific Gravity of Coke", R.I. C.S. 35, Division of Fuel Testing, Department of Mines, Ottawa, August 24, 1934.

13. ASTM Designation: D2014-71, "Expansion or Contraction of Coal by the Sole-Heated Oven".

14. German Industrial Specification No. DIN 51739/March 1951.

15. ASTM Designation: D-2797-72, "Preparing Coal Samples for Microscopical Analysis by Reflected Light".

16. ASTM Designation: D-2798-72, "Microscopical Determination of the Reflectance of the Organic Components in a Polished Specimen of Coal".

17. ASTM Designation: D-2799-72, "Microscopical Determination of Volume Percent of Physical Components of Coal".

18. Schapiro, N., Gray, R.J., "Petrographic Classification Applicable to Coals of all Ranks", Proc. III, Min. Inst., 1960, 68, 83-97.

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APPENDIX 1

Letter dated 28th January 1975, from
D.P. Sharma, Supervisor, Quality Control,
Kaiser Resources.

KAISER RESOURCES

KAISER RESOURCES LTD.
P. O. BOX 2000
SPARWOOD, BRITISH COLUMBIA
604/425-8221
V0B 2G0

January 28, 1975

Mr. J. C. Botham, Head
Cdn. Metallurgical Fuel
Research Laboratory
Dept. of Energy, Mines & Resources
562 Booth Street
Ottawa, Ontario
K1A OG1

Dear Jack:

Ref.: #7 Seam (Adit #88)
Coking Test

Confirming our telephone request of today, we are in the process of shipping 2 drums of Adit #88 coal to Ottawa, Corkstown Rd. Complex. The coal will leave from here on the 29th for Lethbridge for forwarding to Ottawa by Kingsway Transport.

Please run a mw oven coking test on this coal along with bench scale support analyses including petrographic analysis. We would appreciate you issuing a complete report as soon as possible similar to MREC 74/48 completed in June, 1974 on #6 seam. We intend to blend Adit #88 area 7 seam coal with Balmer for Elkview Plant feed and hence need to convince our customers that it will not affect the quality of Balmer export.

Yours very truly,

KAISER RESOURCES LTD.

D. P. Sharma

D. P. Sharma
Supervisor,
Quality Control

cc: L. J. Lindsay
J. B. Murphy
R. H. Gronotte
R. E. Taylor