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MOVABLE-WALL COKE OVEN TESTS AND RELATED ANALYSES  
OF COAL BLENDS SUBMITTED BY ALGOMA STEEL CORPORATION,  
SAULT STE. MARIE, ONTARIO

Project 03-3-0/8-29  
Job No. 3342R

J.G. JORGENSEN AND T.A. LLOYD  
COMBUSTION AND CARBONIZATION LABORATORY

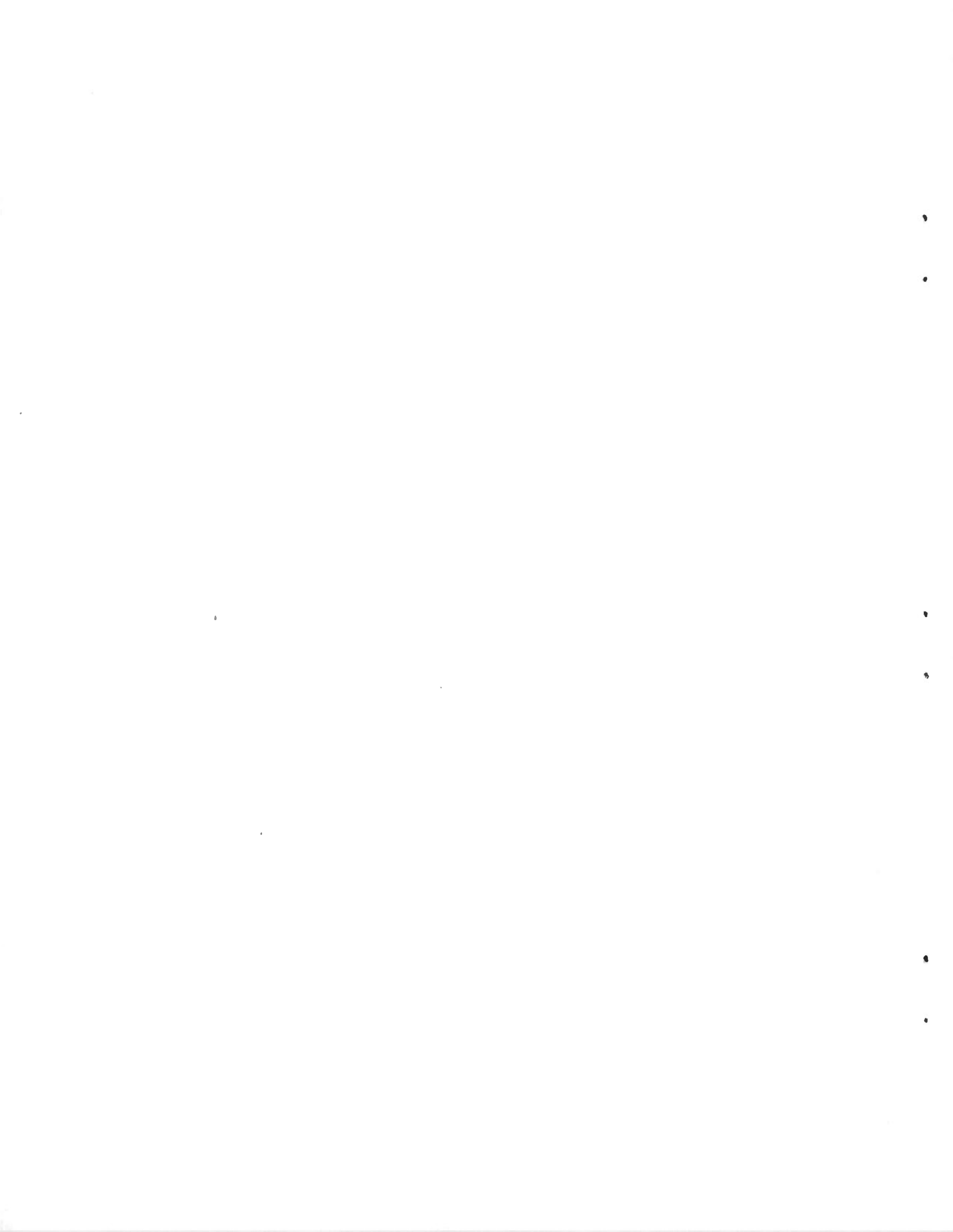
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Movable-Wall Coke Oven Tests and Related Analyses  
of Coal Blends submitted by Algoma Steel Corporation,  
Sault Ste. Marie, Ontario

Project 03-3-0/8-29  
Job No. 3342R

by

J.G. Jorgensen\* and T.A. Lloyd\*\*

INTRODUCTION

The evaluation of coals for use at the coke plant of the Algoma Steel Corporation, Limited, is a continuing divisional project in which periodic investigations are undertaken as requested by the company.

This report is Investigation 32 in the series and includes evaluation data on coals specified in a letter dated February 25, 1981 from M.A. Khan, Senior Research Geologist, Raw Materials Research. A copy of this letter appears in Appendix 1.

The coals which were blended in various ratios and carbonized were Maple Meadow Beckley, Pocahontas, Indian Creek and Kanawha No. 1 and No. 2. These coals were directly from the coal mines. The composition of the coke oven blends are listed in Table 1. The cleaned coal samples were crushed, blended and carbonized in the CANMET 18-inch width movable-wall coke oven. Representative samples were taken for chemical, physical, and thermal rheological testing. The results of the testing program are tabulated in Tables 2 to 11.

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\*Head, Coal Petrography Section, \*\*Head, Carbonization Operations,  
Combustion and Carbonization Laboratory, Energy Research Laboratories,  
CANMET, Department of Energy, Mines and Resources, Ottawa, Ontario Canada.  
KIA OG1

TABLE 1. Composition Of Coke Oven Blends

Blend No.	Oven Test No.	Kanawha-1 (100%-No.5)	Kanawha-2 (75% Mix)	Indian Creek	Maple Meadow	Pocahontas
1	541,542,552	35	-	30	17.5	17.5
2	543,544	-	35	30	17.5	17.5
3	545,546	-	-	65	17.5	17.5
4	547,548	25	-	40	17.5	17.5
5	549,551	-	25	40	17.5	17.5

TABLE 2. Chemical Analyses of Component Coals

<u>Identification</u>	2878-81	2879-81	2880-81	2881-81	2882-81
Laboratory Number .....	2878-81	2879-81	2880-81	2881-81	2882-81
Description .....	POCA	Kanawha No.1 (100%-No.5)	Kanawha No.2 (75% Mix)	Maple Meadow	Indian Creek
<u>Classification</u>					
Rank (ASTM) .....					
International System .....					
Specific Volatile Index .....					
Carbon (dmmfb) .....					
<u>Proximate Analysis (db)</u>					
Ash .....	4.6	6.3	6.1	5.5	6.6
Volatile Matter .....	18.8	33.9	34.0	17.5	35.8
Fixed Carbon .....	76.6	59.8	59.9	77.0	37.6
<u>Gross Calorific Value (db)</u>					
Btu per pound .....					
<u>Ultimate Analysis (db)</u>					
Carbon .....	88.2	79.8	80.8	85.8	78.4
Hydrogen .....	4.8	5.4	5.6	4.8	5.4
Sulphur .....	0.67	0.57	0.62	0.64	1.14
Nitrogen .....	1.6	1.7	1.6	1.6	1.5
Ash .....	4.6	6.3	6.1	5.5	6.6
Oxygen (by difference) .....	0.1	6.2	5.3	1.7	7.0
<u>Ash Analysis (db)</u>					
SiO <sub>2</sub> .....					
Al <sub>2</sub> O <sub>3</sub> .....					
Fe <sub>2</sub> O <sub>3</sub> .....					
TiO <sub>2</sub> .....					
P <sub>2</sub> O <sub>5</sub> .....					
CaO .....					
MgO .....					
SO <sub>3</sub> .....					
Na <sub>2</sub> O .....					
K <sub>2</sub> O .....					

TABLE 3. Chemical Analyses of Component Coals

<u>Identification</u>						
Laboratory Number .....	2883-81	3077-81	3078-81	3106-81	3107-81	
Description .....						
	Blend No.1	Blend No.2	Blend No.3	Blend No.4	Blend No.5	
<u>Classification</u>						
Rank (ASTM) .....						
International System .....						
Specific Volatile Index .....						
Carbon (dmmfb) .....						
<u>Proximate Analysis (db)</u>						
Ash .....	6.0	5.9	6.1	6.0	5.8	
Volatile Matter .....	29.2	28.4	28.5	28.8	29.0	
Fixed Carbon .....	64.8	65.7	65.4	65.2	65.2	
<u>Gross Calorific Value (db)</u>						
Btu per pound .....						
<u>Ultimate Analysis (db)</u>						
Carbon .....	81.7	81.0	81.3	81.1	81.8	
Hydrogen .....	5.1	5.2	5.3	4.7	4.7	
Sulphur .....	0.76	0.83	1.16	0.91	0.94	
Nitrogen .....	1.7	1.4	1.5	1.1	1.1	
Ash .....	6.0	5.9	6.1	6.0	5.8	
Oxygen (by difference) .....	4.7	5.7	4.6	6.2	5.7	
<u>Ash Analysis (db)</u>						
SiO <sub>2</sub> .....						
Al <sub>2</sub> O <sub>3</sub> .....						
Fe <sub>2</sub> O <sub>3</sub> .....						
TiO <sub>2</sub> .....						
P <sub>2</sub> O <sub>5</sub> .....						
CaO .....						
MgO .....						
SO <sub>3</sub> .....						
Na <sub>2</sub> O .....						
K <sub>2</sub> O .....						

TABLE 4. Physical Tests and Fusibility of Ash of Component Coals

<u>Identification</u>			2878-81	2879-81	2880-81	2881-81	2882-81	
Laboratory Number .....								
Description .....			POCA	Kanawha No. 1 (100%-No.5)	Kanawha No. 2 (75% Mix)	Maple Meadow	Indian Creek	
<u>Coal Pulverization</u>								
<u>Sieve Analysis</u>								
Passing	Retained On							
	1/4 in.	%						
1/4 in.	5 mesh	%						
6 mesh	12 mesh	%						
12 mesh	20 mesh	%						
20 mesh	.....	%						
Total Passing	6 mesh	%						
<u>Grindability</u>								
Hardgrove Index .....			99	43	44	93	44	
<u>Fusibility of Ash</u>								
Initial Deformation Temp. ... °F			2130	2700+	2700+	2205	2200	
Softening Temp. Spherical ... °F			2450	2700+	2700+	2700+	2700+	
Softening Temp. Hemispherical ... °F			2600	2700+	2700+	2700+	2700+	
Fluid Temp. .... °F			2645	2700+	2700+	2700+	2700+	

TABLE 5. Physical Tests and Fusibility of Ash of Component Coals

<u>Identification</u>								
Laboratory Number .....		3195-81	3077-81	3078-81	3106-81	3107-81		
Description .....								
		Blend No.1	Blend No.2	Blend No.3	Blend No.4	Blend No.5		
<u>Coal Pulverization</u>								
<u>Sieve Analysis</u>								
<u>Passing</u>		<u>Retained On</u>						
	1/4 in.	%	1.0	1.7	0.4	1.1	0.9	
	6 mesh	%	13.6	15.1	14.9	14.3	13.9	
	12 mesh	%	21.6	21.2	22.5	22.8	22.6	
	20 mesh	%	22.4	21.7	21.7	23.2	23.5	
	.....	%	41.4	40.3	40.5	38.6	39.1	
	Total Passing	6 mesh	%	85.4	83.2	84.7	84.6	85.2
<u>Grindability</u>								
Hardgrove Index .....								
<u>Fusibility of Ash</u>								
Initial Deformation Temp. ...		°F						
Softening Temp. Spherical ...		°F						
Softening Temp. Hemispherical		°F						
Fluid Temp. ....		°F						



TABLE 6. Thermal Rheological Properties of Component Coals

<u>Identification</u>	2878-81	2078-81	2880-81	2881-81	2882-81
Laboratory Number .....	2878-81	2078-81	2880-81	2881-81	2882-81
Description .....	POCA	Kanawha No. 1 (100%-No. 5)	Kanawha No. 2 (75% Mix)	Maple Meadow	Indian Creek
<u>Linear Expansion</u>					
Bd. 52 lb/ft <sup>3</sup> at 2% moisture...%	6.6	-12.5	-14.0	6.1	-12.8
<u>Gieseler Plasticity</u>					
Start .....	445	401	398	445	394
Fusion Temp. ....	459	413	412	458	406
Max. Fluid Temp. ....	481	438	438	480	436
Final Fluid Temp. ....	505	468	471	504	467
Solidification Temp. ....	508	471	473	509	470
Melting Range .....	60	67	73	59	73
Max. Fluidity .....	125	2139	5312	96	5365
Torque .....	40	40	40	40	40
<u>Dilatation</u>					
Ti - Softening Temp. ....	421	375	368	424	369
Tii - Max. Contraction Temp. ....	452	421	416	454	410
Tiii - Max. Dilatation Temp. ....	492	451	447	489	445
Contraction .....	20	26	27	16	29
Dilatation .....	73	40	71	61	100
<u>Free Swelling Index</u>					
F.S.I. ....	9	7	6	8½	7½

TABLE 7. Thermal Rheological Properties of Component Coals

<u>Identification</u>		2883-81	3077-81	3078-81	3106-81	3107-81
Laboratory Number .....		2883-81	3077-81	3078-81	3106-81	3107-81
Description .....						
		Blend No.1	Blend No.2	Blend No.3	Blend No.4	Blend No.5
<u>Linear Expansion</u>						
Bd. 52 lb/ft <sup>3</sup> at 2% moisture...%		-4.4	-5.3	-5.9	6.4	-6.1
<u>Gieseler Plasticity</u>						
Start .....	°C	409	409	408	408	409
Fusion Temp. ....	°C	421	419	418	418	418
Max. Fluid Temp. ....	°C	444	442	442	443	442
Final Fluid Temp. ....	°C	476	477	478	477	477
Solidification Temp. ....	°C	480	481	481	480	482
Melting Range .....	°C	67	68	70	69	68
Max. Fluidity .....	dd/m	487	680	550	525	710
Torque .....	g.in.	40	40	40	40	40
<u>Dilatation</u>						
Ti - Softening Temp. ....	°C	376	385	379	389	381
Tii - Max. Contraction Temp. ....	°C	423	422	422	424	421
Tiii - Max. Dilatation Temp. ....	°C	456	457	460	461	457
Contraction .....	%	26	24	26	27	27
Dilatation .....	%	16	24	26	20	24
<u>Free Swelling Index</u>						
F.S.I. ....		7	7½	7½	7½	7½

TABLE 8. CARBONIZATION DATA

Test Identification Number.....	541	542	552	543	544	
Data of Test.....	4/5/81	25/5/81	11/6/81	26/5/81	27/5/81	
Laboratory Number.....	Blend	Blend	Blend	Blend	Blend	
Description.....	No.1	No.1	No.1	No.2	No.2	
<u>CARBONIZATION DATA</u>						
Net Weight of Charge (wet).....lb.	731.9	682.7	699.1	703.0	697.4	
Moisture in Charge.....%	4.3	5.9	4.9	4.9	4.9	
ASTM Bulk Density (wet).....lb/ft <sup>3</sup>	42.3	40.1	41.0	41.6	41.6	
Oven Bulk Density (db).....lb/ft <sup>3</sup>	48.7	44.7	46.2	46.5	46.1	
<u>CARBONIZATION RESULTS</u>						
Gross Coking Time.....hr:min.	19:45	19:50	19:30	19:45	19:40	
Maximum Wall Pressure.....lb/in.	0.81	0.23	0.28	0.33	0.22	
Coke Yield Actual.....%	71.9	73.0	72.8	74.0	73.3	
Mean Coke Size.....in.	2.62	2.58	2.61	2.59	2.56	
Apparent Specific Gravity.....	0.823	0.800	0.813	0.803	0.802	
<u>SCREEN ANALYSIS OF COKE</u> (cumulative percentage retained on)						
3 inch sieve.....	34.4	31.3	32.1	32.0	29.7	
2 inch sieve.....	69.3	71.1	73.2	69.4	70.7	
1½ inch sieve.....	87.4	88.0	88.5	88.0	88.1	
1 inch sieve.....	96.1	94.8	95.4	95.6	95.8	
¾ inch sieve.....	97.1	96.7	96.3	96.5	96.6	
½ inch sieve.....	97.7	97.3	96.9	97.3	97.4	
Percentage -½ inch (breeze).....	2.3	2.7	3.1	2.7	2.6	
<u>TUMBLER TEST (ASTM)</u>						
Stability Factor.....	58.6	56.1	58.7	57.9	58.0	
Hardness Factor.....	66.0	64.1	65.8	65.2	65.3	
<u>JAPANESE DRUM TEST (JIS)</u> (cumulative percentage retained on)						
	* **	* **	* **	* **	* **	
50 mm sieve.....	48.6 27.4	26.8 10.1	39.4 12.1	36.6 11.6	40.5 21.0	
25 mm sieve.....	92.0 79.0	90.9 77.0	91.8 77.1	90.7 75.8	91.0 77.5	
15 mm sieve.....	94.7 84.1	94.5 83.3	94.7 84.0	93.3 82.1	94.6 83.6	
	* 30 revs ** 150 revs					

TABLE 9. CARBONIZATION DATA

Test Identification Number.....	545	546	547	548	549	551
Data of Test.....	28/5/81	1/6/81	2/6/81	3/6/81	4/6/81	10/6/81
Laboratory Number.....	Blend	Blend	Blend	Blend	Blend	Blend
Description.....	No.3	No.3	No.4	No.4	No.5	No.5
<u>CARBONIZATION DATA</u>						
Net Weight of Charge (wet).....lb.	711.9	725.0	697.9	696.2	689.5	700.4
Moisture in Charge.....%	4.2	4.6	4.8	4.8	4.8	4.5
ASTM Bulk Density (wet).....lb/ft <sup>3</sup>	41.0	40.8	40.7	40.7	40.6	41.0
Oven Bulk Density (db).....lb/ft <sup>3</sup>	47.4	48.1	46.2	46.1	45.6	46.5
<u>CARBONIZATION RESULTS</u>						
Gross Coking Time.....hr:min.	19:55	19:45	19:35	19:30	19:50	19:40
Maximum Wall Pressure.....lb/in.	0.42	0.46	0.31	0.29	0.32	0.45
Coke Yield Actual.....%	72.1	70.9	73.4	71.7	72.6	72.8
Mean Coke Size.....in.	2.72	2.68	2.62	2.52	2.65	2.54
Apparent Specific Gravity.....	0.803	0.793	0.803	0.802	0.798	0.797
<u>SCREEN ANALYSIS OF COKE</u> (cumulative percentage retained on)						
3 inch sieve.....	38.9	36.8	33.1	30.1	31.7	30.9
2 inch sieve.....	73.5	73.7	71.7	67.6	74.2	70.4
1½ inch sieve.....	90.1	89.7	89.1	86.3	89.4	88.6
1 inch sieve.....	95.9	95.6	96.0	95.3	96.3	95.7
¾ inch sieve.....	96.8	96.5	96.9	96.6	97.1	96.7
½ inch sieve.....	97.6	97.2	97.5	97.3	97.6	97.3
Percentage -½ inch (breeze).....	2.4	2.8	2.5	2.7	2.4	2.7
<u>TUMBLER TEST (ASTM)</u>						
Stability Factor.....	57.2	56.5	56.9	57.0	57.7	57.7
Hardness Factor.....	63.6	63.1	65.1	64.3	63.9	64.5
<u>JAPANESE DRUM TEST (JIS)</u> (cumulative percentage retained on)						
	* **	* **	* **	* **	* **	* **
50 mm sieve.....	51.6 22.7	27.5 13.1	55.1 28.8	34.8 16.6	47.0 22.4	36.9 14.3
25 mm sieve.....	90.4 76.2	91.0 76.3	92.0 77.5	90.0 75.5	91.3 76.8	90.4 75.6
15 mm sieve.....	94.1 82.7	94.1 82.8	94.4 82.5	93.8 82.4	94.0 83.0	94.1 83.1
	* 30 revs ** 150 revs					

TABLE 10.

Analyses of Coke Oven Charges and Resultant Cokes

<u>Identification</u>	541	542	552	543	544	545	546
Test Number.....	541	542	552	543	544	545	546
Date Charged.....	4/5/81	25/5/81	11/6/81	26/5/81	27/5/81	28/5/81	1/6/81
Description.....	Blend	Blend	Blend	Blend	Blend	Blend	Blend
	No.1	No.1	No.1	No.2	No.2	No.3	No.3
<u>Coke Oven Charge</u>							
Laboratory Number.....	2883-81		3195-81	3077-81		3078-81	
<u>Proximate Analysis (db)</u>							
Ash.....%	6.0		5.8	5.9		6.1	
Volatile Matter.....%	29.2		28.3	28.4		28.5	
Fixed Carbon.....%	64.8		65.9	65.7		65.4	
Sulphur (db).....%	0.76		0.82	0.83		1.16	
<u>Resultant Coke</u>							
Laboratory Number.....	2945-81	3376-81	3386-81	3077-81	3378-81	3379-81	3380-81
<u>Proximate Analysis (db)</u>							
Ash.....%	7.8	7.8	7.7	7.8	7.9	8.1	8.1
Volatile Matter.....%	1.0	1.3	1.2	1.0	1.5	1.0	1.5
Fixed Carbon.....%	91.2	90.9	91.1	91.2	90.6	90.9	90.4
Sulphur (db).....%	0.64	0.61	0.61	0.65	0.68	0.76	0.74

TABLE 11.

Analyses of Coke Oven Charges and Resultant Cokes

<u>Identification</u>					
Test Number.....	547	548	549	551	
Date Charged.....	2/6/81	3/6/81	4/6/81	10/6/81	
Description.....	Blend No.4	Blend No.4	Blend No.5	Blend No.5	
<u>Coke Oven Charge</u>					
Laboratory Number.....	3106-81		3107-81		
<u>Proximate Analysis (db)</u>					
Ash.....%	6.0		5.8		
Volatile Matter.....%	28.8		29.0		
Fixed Carbon.....%	65.2		65.2		
Sulphur (db).....%	0.91		0.94		
<u>Resultant Coke</u>					
Laboratory Number.....	3381-81	3382-81	3383-81	3385-81	
<u>Proximate Analysis (db)</u>					
Ash.....%	7.9	7.6	7.8	7.7	
Volatile Matter.....%	1.5	1.3	1.3	1.0	
Fixed Carbon.....%	90.6	91.1	90.9	91.3	
Sulphur (db).....%	0.68	0.66	0.64	0.68	

APPENDIX 1

Letter dated February 25, 1981 from M.A. Khan, Senior  
Research Geologist, Raw Materials Research, Algoma Steel Corporation,  
Limited.

The Algoma Steel Corporation, Limited      Sault Ste. Marie  
Ontario, Canada  
P6A 5P2

February 25, 1981

Mr. T.D. Brown  
Manager, Carbonization Section  
CANMET, Department of Energy, Mines and Resources  
555 Booth Street  
Ottawa, Ontario K1A 0G1

Dear Dave:

In conjunction with the evaluation of some of our new coals, we are planning to initiate carbonization trials using 18" oven at Canmet Laboratories in Ottawa.

This program was verbally discussed with Messrs. Gransden and Gardner last week. It is our understanding that the oven facilities will be available for the above trials some time in the later part of March.

We will therefore make arrangements to ship the required coal quantities from our mines accordingly.

The details of this program has been outlined in the attached sheet. We are planning to coordinate this program very closely and will be visiting Canmet facilities during the trials.

A cost order to cover the cost of the above work will be issued as soon as we receive the breakdown of the estimated cost of this investigation.

If you have any further questions regarding the above program, please contact me.

Yours truly,

THE ALGOMA STEEL CORPORATION, LTD.



M.A. Khan  
Senior Research Geologist  
Raw Materials Research

MAK/mm  
Attachment

C.C.: H. Lien  
G. Sagle  
A. Cameron  
P. Paciocco  
R. Fabbro  
L. Fish



PROJECT: NO. 5 BLOCK STUDY

PROGRAM:

The following blends are planned to be tested in duplicate using 18" oven:

<u>Coals</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Kanawha - 1	35	-	-	25	-
Kanawha - 2	-	35	-	-	25
Indian Creek	30	30	65	40	40
Maple Meadow	17.5	17.5	17.5	17.5	17.5
Pocahontas	17.5	17.5	17.5	17.5	17.5

In addition to the above oven trials, we would like to test all the component coals and blends for proximate, ultimate, rheological and sole-heated oven tests.

Coals Being Shipped:

	<u>Quantities</u>	<u>Barrels</u>
Kanawha - 1	1300 lbs.	4
Kanawha - 2	1300 lbs.	4
Indian Creek	4225 lbs.	13
Maple Meadow	1625 lbs.	5
Pocahontas	1625 lbs.	<u>5</u>
	TOTAL	31 Barrels

