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GRINDABILITY INDICES OF TYPICAL CANADIAN AND OTHER COALS AND THE RELATION OF GRINDABILITY TO FRIABILITY

by

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Preface

For the use of coals in the pulverized form, the determination of their grindability, or the relative ease with which they can be pulverized, is of great importance. Grindability is considered as important a factor as calorific value in the selection of a coal for pulverized fuel purposes. By means of a standard grindability test, it is possible to predict the general pulverizing characteristics of a coal and to indicate its relative value in commercial pulverizers in comparison with a standard coal, the mill performance for which is known.

It is to be noted that the grindability tests reported in this paper were made by the Hardgrove-machine method, and that this method was developed by a commercial firm which manufactures and installs pulverized fuel boiler installations. As for the relation between grindability and pulverizer capacity, the originator of this method, after studying the results of tests in a large number of different sizes of pulverizers, has stated[a] that pulverizer capacity "is proportional to grindability up to about 60 grindability index, but falls off at the higher grindabilities". This should be borne in mind when interpreting the results for the softer coals showing the higher grindability indices. The correlation of the indices by the Hardgrove-machine method with those of the Ball-mill method, both of which are standard A.S.T.M. tests, is also noteworthy.

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a/ "The relation between pulverizing capacity, power, and grindability" by R.M. Hardgrove--A.S.T.M. Advance paper M.T.G. June 25 to July 1, 1933, and p. 370 A.I.M.E. Coal Division, 1936. See also "Correlation of Grindability with Actual Pulverizer Performance" by M. Frisch and G.C. Holder--Combustion, June-July, 1933.

This report comprizes the results of routine grindability tests carried out at the Fuel Research Laboratories during the last seven years. The earlier determinations were made by H. P. Hudson, and those since 1936 by W. Kritsch. The reader solely interested in ascertaining the grindability indices of the coals tested is referred immediately to Table III, in which, it is of interest to note, about half of the samples listed pertain to coals collected as part of a Physical and Chemical Survey of coals from Canadian collieries. This survey is now complete for Nova Scotia and New Brunswick, which accounts for the preponderance of coals from the Maritime provinces. Coals from the producing fields in Alberta and British Columbia will be tested for grindability as the survey is extended to the western provinces.

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The Grindability indices tabulated in this report were determined by the A.S.T.M.* "Hardgrove-machine" method[1]. An alternative A.S.T.M. method is the "Ball-mill" method[2]. At the end of the description of each of these methods, there is shown a table for converting the indices obtained by one method into those of the other method of test. Hence, for all indices obtained by the Hardgrove method and reported here, the equivalent Ball-mill indices have been derived and included.

In the section on "Scope", in the specifications of the Hardgrove-machine method, it is stated that the method is based on Rittinger's Law, namely: the work done in pulverizing is proportional to the new surface produced and that the method is used to "determine the relative grindability, or ease of pulverizing, of coals in comparison with a coal chosen as 100 grindability". By this method, a prepared sample receives a definite amount of grinding in a miniature pulverizer, the new surface being determined by sieving. In the Ball-mill method, the relative amounts of energy necessary to pulverize different coals are determined by placing a

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* American Society For Testing Materials; below is a reference list of the A.S.T.M. Designations mentioned in this report.

1/ D 409-37T - Tentative Method of Test for Grindability of Coal by the Hardgrove-machine method.
2/ D 408-37T - Tentative Method of Test for Grindability of Coal by the Ball-mill method.
3/ D 388-37 - Standard Specifications for Classification of Coals by Grade.
4/ D 388-38 - Standard Specifications for Classification of Coals by Rank.
5/ D 441-37T - Tentative Method of Tumbler Test for Coal.

Erratum

p. 2, first three lines should read:

" sample of each coal in a ball-mill, and finding the number of revolutions required to grind it so that eighty per cent of it passes a 74 (No. 200) A.S.T.M. sieve."

ball-mill, and finding the number of revolutions required to grind it so that eighty per cent of it passes a 74 (No. 200) A.S.T.M. sieve.

Calculation of Results by Hardgrove-machine Method

In the latest revision of the A.S.T.M. method, namely: D 409-37T, which is still "Tentative" (T) rather than "Standard", the directions for "calculation of results" have been changed from those specified in the original A.S.T.M. draft, namely: D 409-35T. In the present report, these are known as the "old" or original, and the "new" or revised formulas for calculating the grindability index from the screen analysis of the pulverized material.

The original formula specified in the 35T (1935 Tentative) draft is as per (1) below, where the surface unit factor 1200 divided by $\frac{Y1 + Y2}{2}$ is used; Y1 and Y2 being the openings of the two screens limiting a given size of particles, expressed in microns.

(1) $\text{Grindability} = \frac{\text{New surface produced}}{\text{New surface units of 100 grindability coal}}$

(2) Hardgrove grindability index = $13 + 6.93W$

The latter, namely: (2), is the revised formula given in the 37T (1937 Tentative) draft, where W is the weight of material from a 50-gram sample passing the 74-micron (No. 200) sieve.

All investigators and other interested readers should consult the details as given in the A.S.T.M. publications referred to above. However, for ready reference, a comparison of the two methods of calculating the results may be outlined here, for which purpose the typical calculation shown in D 409-35T may be used.

Designation		Grams of Material Between the Two Sieves	Surface Unit Factor	Final Surface Units
Micron Designation	U. S. Standard Sieve Series Number			
1190 to 590	No. 16 to 30	14.3	1.35	19.3
590 to 250	No. 30 to 60	17.3	2.86	49.5
250 to 149	No. 60 to 100	6.4	6.02	38.6
149 to 105	No. 100 to 140	3.2	9.45	30.3
105 to 74	No. 140 to 200	2.2	13.4	29.5
74 to 62	No. 200 to 230	1.4	17.7	24.8
62 to 44	No. 230 to 325	0.6	22.6	13.6
44	Passing No. 325	4.6	47.5	219.0
Total.		(50.0)		(424.6)

Final surface units of sample 424.6
Original surface units (50 gms. of sample, 16 to 30 sieve size) -67.5
New surface units produced. 357.1
New surface units of 100 grindability sample (assumed). 656

Weight passing 200-mesh sieve (weight of original sample minus weight of material retained on 74 micron sieve = 50 - 43.4 . 6.6

Hardgrove-machine Grindability Index:-

by original (D 409-35T) formula = 357.1 divided by 656 . . . . 54.4
by revised (D 409-37T) formula = 13 + 6.93 x 6.6 . . . . . . 58.7

Obviously, the advantage of the method using the revised calculation formula is that in screening the coal after pulverizing, it is necessary to use only one screen instead of seven as required by the original method for calculating the grindability index.

Grindability Indices and Analyses of Coals in Table III

The grindability indices of 228 coals are reported in Table III. In addition to a description of each coal, in terms of mine or trade designation, seam, and size or other description, its volatile matter and fixed carbon contents on the "dry basis" and its rank and grade classification are shown.

The symbols employed to indicate rank and grade follow those in A.S.T.M. Designation D 389-37[3]. The data in parenthesis, e.g.: (65-154), represent respectively the fixed carbon percentage to the nearest whole number on the dry mineral-matter-free basis, and the B.t.u. per pound to the nearest hundred on the "as sampled" mineral-matter-free basis. It is observed in the footnote at the bottom of the first page of Table III that the B.t.u. values only roughly indicate the rank, since for this purpose the B.t.u. on the moist (capacity moisture) basis should be used. On this basis, the correct B.t.u. values to be employed for rank classification purposes might be less than those shown, as much as 400 B.t.u. For some of the higher rank coals the values would not change much, but they would be considerably lower for certain of the lower rank coals, due to the "capacity moisture" content being higher than that indicated on the "as sampled" basis.

An example of the symbols indicating grade is M1-138-A9-S4, where M1 is the moisture content percentage (on the "as sampled basis) to the nearest whole number, and 138 is the B.t.u. per pound value to the nearest hundred. Interpretation of the symbols A for ash and S for sulphur, is according to the following table.

Ash				Sulphur	
Symbol	Per cent inclusive	Symbol	Per cent inclusive	Symbol	Per cent inclusive
A 4	0.0 to 4.5	A13	12.6 to 13.5	S0.7	0.0 to 0.7
A 5	4.6 to 5.5	A14	13.6 to 14.5	S1.0	0.8 to 1.0
A 6	5.6 to 6.5	A15	14.6 to 15.5	S1.3	1.1 to 1.3
A 7	6.6 to 7.5	A16	15.6 to 16.5	S1.6	1.4 to 1.6
A 8	7.6 to 8.5	A17	16.6 to 17.5	S2	1.7 to 2.0
A 9	8.6 to 9.5	A18	17.6 to 18.5	S3	2.1 to 3.0
A10	9.6 to 10.5	A19	18.6 to 19.5	S4	3.1 to 4.0
A11	10.6 to 11.5	A20	19.6 to 20.5	S5	4.1 to 5.0
A12	11.6 to 12.5	A20+	20.6 & higher	S5+	5.1 & higher

The symbols for sulphur follow those in D 389-37[3], A.S.T.M to which has been added S4 for the 3.1 to 4.0 range of sulphur percentages. The symbols for ash, it will be noticed, depart somewhat from those in D 389-37. This in reality means the reporting of the ash percentages to the nearest whole number, with one exception, namely: A20+.

The three temperatures recorded in the F.P.A. determination, namely: the Initial Deformation, Softening and Fluid Temperatures, are reported in full in Table III, instead of using symbols. These are important criteria in relation to the use of coal as pulverized fuel.

The grindability indices obtained by the Hardgrove-machine method are reported to the nearest whole number on two bases, namely: by the original and revised calculation formulas. The equivalent Ball-mill method indices, shown also to the nearest whole number in the last column to the right in Table III, were derived by means of a curve obtained by employing the conversion data in the appendix of D 409-37T[1/]. These conversion data have been expanded to show the Ball-mill indices corresponding to each whole index number from 16 to 120 by the Hardgrove-machine method, and comprize Appendix of the present report.

The relation of the indices obtained by these two methods on a set of five standard coals has been previously published[6/] in connexion with the development of the methods by the A.S.T.M. Sub-committee on Grindability. In the report just referred to, the indices by the F.R.L. method, developed at the Fuel Research Laboratories, are also shown; this method, it may be noted, was a forerunner of, and similar to, the Ball-mill method developed by the U.S. Bureau of Mines. The relation of the indices by the F.R.L. method to those of both the Ball-mill and Hardgrove-machine methods on several typical Canadian coals has also been published[7/]

Relation of Grindability to Friability

The relation of grindability to friability may be ascertained by comparing the friability results obtained on forty-eight

6/ "Check Determinations of Grindability of Coal by Various Methods" by W.A. Selvig - R.I. 3301, U.S. Bureau of Mines.

7/ "The F.R.L. Method for Rating the Grindability or Pulverizability of Coal Correlated with the 'Cross' and 'Hardgrove' methods" by C.E. Baltzer and H.P. Hudson.

of the coals reported in Table III with their grindabilities. The friability tests were made in accordance with the A.S.T.M. Tumbler Test for Coal, D 441-37T[5]. In this test, 1000 grams of 1 to 1½ inch (square hole screen size) lumps are tumbled for one hour in a porcelain jar tumbler specially fitted with an iron frame with lifting shelves, and by means of a screen analysis of the tumbled coal the reduction in size is calculated and expressed as "friability per cent".

The friability percentages on the coals, on which both friability and grindability results are available, are given in Table I, where the grindability results reported are those obtained by the revised formula specified in the 1937 draft of the Hardgrove-machine method. The friability results, as mentioned above, are for the 1 to 1½ inch lumps prepared on square hole screens, while the grindability indices are for either the 'domestic lump' size, composed mostly of lumps with varying amounts of fines, or for the -4 inch (round hole screen) composite including lumps, smalls, and fines. As will be noticed, the coals are arranged in five groups according to rank; and in each group according to increasing friability. The group designations here, as in Table II, follow those in the A.S.T.M. classification by rank[4]. Under friability results, the abrasion (dust) index is shown for each coal, in addition to the friability per cent. This index is the percentage of "fines and dust" passing the 0.0117-inch (No. 48) mesh screen, and represents the proportion of the breakage occurring during the tumbler test that is considered to be due to attrition or abrasion rather than to shattering.

In a previous paper[8], limits were suggested for grouping coals according to friability per cent values obtained by the tumbler

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8/ "Significance of Friability and Size Stability Tests on Coals" by R.E. Gilmore and J.H.H. Nicolls - A.S.T.M. Proceedings, Vol. 37 (1937), Part II.

TABLE I - Comparison of Friability & Grindability Results on 48 Coals

Laboratory Number and Rank	Dry Fixed Carbon to nearest whole number and As Rec'd B.t.u. to nearest hundred on the mineral matter-free basis	Friability Results on 1 to 1-1/2 inch (square mesh) Lumps: Friability Per cent	Friability Results on 1 to 1-1/2 inch (square mesh) Lumps: Abrasion (dust) Index	Grindability Index by the Hardgrove-Machine Method on the domestic lump, or minus 4-inch sizes (composite)
Semi-anthracite (Welsh and Westphalian)				
16281	(92-150)	26.5	(18)	48
16141	(90-153)	34.0	(20)	54
Low and Medium Volatile Bituminous				
18853	(72-152)	21.5	(13)	77
18907	(70-151)	21.5	(14)	84
16202	(83-156)	40.0	(28)	98
17455	(76-154)	43.0	(25)	88
High Volatile A Bituminous				
18947	(68-154)	26.5	(15)	76
19073	(66-147)	27.0	(12)	58
16459	(57-146)	27.0	(13)	68
18778	(66-145)	27.0	(12)	60
16505	(56-147)	28.5	(14)	70
18715	(66-143)	29.0	(12)	62
14334	(59-149)	31.0	(15)	66
16400	(62-148)	31.0	(14)	65
19357	(61-152)	31.5	(12)	71
14847	(61-146)	32.0	(15)	72
18146	(60-142)	32.5	(16)	70
19750	(63-154)	33.0	(17)	65
15217	(66-150)	33.0	(19)	85
18265	(60-141)	33.0	(14)	61
19484	(64-155)	34.0	(17)	69
13245	(63-149)	34.0	(16)	77
19002	(68-150)	35.5	(14)	66
16371	(64-151)	35.5	(19)	66
14805	(60-148)	36.0	(16)	69
14046	(69-146)	36.2	(29)	71
15683	(64-153)	36.0	(19)	77
19608	(64-152)	36.0	(17)	74
19551	(63-153)	36.5	(17)	73
15799	(63-152)	38.0	(18)	78
19265	(61-152)	39.0	(19)	73
13687	(64-152)	39.0	(19)	75
18377	(62-143)	39.0	(16)	68
18441	(60-145)	39.0	(17)	66
15165	(67-152)	41.5	(15)	86
19689	(64-152)	41.5	(18)	80
19232	(68-150)	41.5	(17)	72
15519	(65-153)	43.0	(24)	76
16394	(65-154)	43.5	(22)	72
15590	(64-143)	43.5	(20)	71
18648	(59-145)	44.0	(20)	75
18560	(58-147)	44.0	(19)	76
High Volatile B & C Bituminous				
17829	(57-132)	24.0	(13)	62
19425	(59-134)	30.0	(12)	65
18011	(63-135)	32.0	(12)	62
14333	(56-131)	32.0	(15)	59
17925	(58-126)	36.0	(15)	62
Lignite				
16275	(57- 81)	21.0	(7)	54

test. These were:- below 20 for non-friable coals; 20 to 40 for medium friable; 40 to 50 for friable; and above 50 for very friable coals. Of the forty-eight coals reported in Table I, thirty-eight are in the medium friable group, with the remainder in the friable group. The non-friable and the very friable groups are not represented. The grindability indices for the nine coals with friability percentages well within the limits of the "friable" group are 71 to 88, in which range are to be found many of the "medium friable" coals. Over half of the coals in the latter group, however, have grindability indices below 71, ranging as low as 48, while one coal on the borderline between the medium friable and friable groups has a grindability index of 98.

In view of this overlapping, it is difficult to draw conclusions from the results reported in Table I. Casually, it would appear that, as expected, there is some relation between friability and grindability, but the relation is very general only and not at all specific. This conclusion is allowable if the coal with the highest grindability index is treated as an exception, and when keeping in mind that over half of the medium friable coals have grindability values below the lower limit of the coals in the friable group. Further data on a larger number of coals, and especially on a wider range in respect to friability, are required before any definite conclusions can be drawn.

In respect to rank, it is to be noted that both the friability percentages and grindability indices are generally low for the (two) semi-anthracites, high for the four low and medium volatile coals (with the exception that the two medium volatile coals have low friabilities), medium to high for the thirty-six coals in the high volatile A bituminous group, medium for the high volatile C bituminous coals, and back to low for the single sample of lignite reported. A considerable overlapping of the values from one group of coals to another, and particularly for the three groups of bituminous coals, is noticeable.

For the thirty-six high volatile A bituminous coals examined, showing friability percentages ranging from 27 to 44 and grindability indices from 58 to 86, the general tendency was for the grindability indices to increase with the increase in friability values, but in specific cases this relation failed to hold. For example, for the three coals with 33.0 friability per cent, the grindability indices were 61, 65, and 85, while for the three coals with 41.5 friability per cent, the corresponding grindability indices were 72, 80 and 86.

The abrasion (dust and fines) indices, which generally increased as the friability per cent values became higher, failed to show a consistent and specific relation to the pulverizability of the coals as judged by their grindability indices.

The friability test, it may be reiterated, is made on lumps of coal larger than 1-inch, and the grindability test on coal previously reduced in size so that all of the sample passes a 16-mesh sieve and remains on a 30-mesh sieve; the fines and dust smaller than this being discarded. While the action upon the coal is somewhat similar in each test, namely: to materially reduce the particle size in the sample by standardized procedures, the friability test serves to ascertain the relative ease of crushing the lumps of coal by shattering and abrasion, whereas the grindability test serves to ascertain the relative ease of pulverization of the particles already considerably reduced in size. That is, the friability test serves to compare coal in respect to general softness in the lump form, and the grindability test to compare them as to ease of preparation for use as pulverized fuel.

The above discussion on the relation of friability to grindability serves to emphasize the necessity of making grindability index determinations rather than relying on friability results to indicate relative pulverizability.

Variation of Indices for Standard Coal

Below are given the indices obtained for the "Emore" coal, originating from the Upper Kittaning Seam of the Jerome Mine, Somerset County, Pennsylvania, and used as standard at the Fuel Research Laboratories since the Hardgrove machine was installed in 1932.

Sample, and when tested	Grindability Index (Calculation Formula Used)	
	Original	Revised
First (1-quart) sample received with machine--		
Tested Nov. 1932--Average of 2 determinations	(98)	104
Tested Jan. 1938--Average of 2 determinations	(98)	103
Second (25-pound) sample received later--		
Tested Nov. 1933--Average of 2 determinations	(102)	109
Tested May 1934--Average of 2 determinations	(100)	109
Tested Jan. 1938--Average of 2 determinations	(102)	107
Tested Jan. 1939--Average of 4 determinations	(96)	97

Appreciable differences between the indices for the two samples of the same "standard" coal, and especially the variation in the results obtained on the second sample are noticeable. For some reason not discernable at the time of the release of this report, the indices obtained in 1939, so far, have been much lower. Changes in the condition of the standard sample may account for this variation, namely: either deterioration by oxidation; too fine grounding during preparation for test, with consequent loss of (higher index) fines through the 30-mesh sieve; or a combination of these two factors. Other factors to be considered are: change in the sieves used; a change in the grinding balls and ball race; or even a change in the mounting of the machine during alterations of the laboratory bench on which it was operated.

In case of irregularities, such as tabulated above, changes in the machine may be discovered by testing the same sample, or samples, in two or more machines. Should the results of such tests fail to agree, the sieves should, if possible, be checked against standardized sieves. Both of these procedures are being followed at these laboratories in collaboration with other laboratories.

At this point may be mentioned the desirability of finding a mineral other than coal, that can be used as a standard material for which the grindability index obtained by a given method will not be subject to change by oxidation or other deterioration factor. Such a standard mineral could then be employed either alone or in conjunction with a standard coal sample.

Effect of Revision of Index Calculation Formula

Differences between the grindability values obtained with the "old" and "new" formulas were studied in some detail. It was found that, for the 228 coals reported in Table III, the differences between the old and new values ranged from as low as 0.1 to as high as 9.4. The average of these differences amounts to about 2.3, which agreement, or rather lack of agreement, between the old and new values is not quite as close as the agreement which is expected between two grindability determinations in the same laboratory.

Furthermore, it should be borne in mind that the indices by the Hardgrove-machine method, designated as "new" in Table III, are relative only one to another, and to the values obtained for the standard coal, ranging from 97 to 109. It should also be kept in mind that the new formula indices were used for deriving, by means of a curve, the Ball-mill equivalent indices.

Discussion of Grindability Results

The grindability indices reported in Table III may be discussed in respect to size designation, rank and grade classification, and geographical origin. Nearly half of the indices are for thirty-nine coals for which three different sizes were tested, namely: minus 4-inch composite, 3/4-inch slack, and minus 1/8-inch fines. For approximately half of these, there was a normal increase in the grindability index as the size designation decreased, that is, as the size of lumps became smaller. This increase averaged about four units as the difference between the index for the 3/4-inch slack and that for the minus 4-inch composite, and approximately the same difference for the 1/8-inch fines above that for the 3/4-inch slack.

This indicates that the minus 1/8-inch fines are softer and easier to pulverize than the larger sized particles and lumps. Whether or not this indicated greater ease of pulverization of the fines would be appreciable in connection with the commercial operation of paddle or impact mills is debatable, since, for such pulverizers, the optimum size composition of the feed is generally much coarser than 1/8-inch, 1-inch slack being a typical size designation of the coal used. For either ball-mill or roller-mill pulverizers, however, there seems to be no reason why the relatively high grindability of the 1/8-inch fines should not be a factor in their favour.

Although there are several coals reported in Table III, for which the ash content of the fines is the same as, or less than, that for the 3/4-inch slack, the large majority show appreciably higher ash values in the fines, which increase ranges as high as 6 and 8 per cent. The calorific values of these higher ash fines were, of course, correspondingly lower. The grindability indices of nine different sized lumps and fines of Princess (N. S.) and Hutchinson (Pa.) coals are noteworthy. For these coals, the ranges of indices were 15 and 10 respectively, the indices being progressively higher as the size of lumps varied from the plus 4-inch to the minus 4-inch sizes. Higher indices for the smaller sizes are not, however, always the case, as several instances are to be found where the indices for the 1/8-inch fines are the same as, or lower than, those for the 3/4-inch slack. In practice, the grindability index, when considered in conjunction with the grade as indicated by the ash content and calorific value and also with the cost of the fuel, should serve to decide what coal and what size designation of it is best to select for use as pulverized fuel.

A summary of the results reported in Table III is given below as Table II, in which the coals are grouped according to geographical source, and according to rank from anthracites to lignite. In this table, the ranges of grindability indices by the Hardgrove-machine method are shown for the coals arranged according to producing area, and source in Canada, the United States, and elsewhere. The results for the samples designated as "minus 1/8-inch fines" are not included in Table II.

As mentioned above in referring to the relation of grindability to friability, there is considerable overlapping of the grindability indices in the different (rank classification) groups, but despite this, it is confirmed that the indices are relatively low for the anthracites, high for the low and medium volatile bituminous groups, medium to high for the high volatile A bituminous (Canadian and U.S.A.) coals, and relatively low for the Alberta high volatile C bituminous and sub-bituminous coals and for the two lignites. This observation as to the general relation of grindability to rank agrees with that reported[9] for a limited number of United States coals.

9/ "Ball-mill Grindability Indexes of Some American Coals" by H. F. Yancey and M. R. Geer -- R.I. 3409, U.S. Bureau of Mines.

Therefore, although the grindability of a coal seems to be predictable, as being within a certain range, through a knowledge of the source, rank and grade of the coal, it appears to be necessary to make an actual grindability determination when detailed and exact information is desired in connection with plant operation.

TABLE II

Summary of Grindability Indices by the Hardgrove-Machine Method for Coals Grouped According to Rank and Geographical Source

Geographical Source and Rank Classification	Number of Samples	Range of Grindability Indices by Revised Calculation Formula
Anthracites		
Pennsylvania..... (anthracite)...........	4	29, 31, 32 & 52
French Indo-China (anthracite)...........	2	34 & 35
Russian.......... (anthracite)...........	2	34 & 34
Welsh......(anthracite & semi-anthracite)	9	48 to 58
Westphalian(anthracite & semi-anthracite)	4	54, 54, 55 & 62
Low & Medium Volatile Bituminous		
Pa. & W.Va..... (Low volatile bituminous)	4	98, 98, 100 & 107
Pa.......... (Medium volatile bituminous)	2	76 & 101
Alta. & B.C. (Medium volatile bituminous)	7	75 to 102
N.S.-Westville(Medium volatile bituminous)	5	73 to 84
High Volatile A Bituminous		
N.S.--Springhill area... (Cumberland co.)	9	71 to 103
N.S.--Sydney area... (Glace Bay district)	20	61 to 81
N.S.--Sydney area (Sydney Mines district)	13	61 to 78
N.S.--Inverness area..... (All districts)	14	59 to 71
N.S.--River Hebert area. (Cumberland co.)	7	66 to 76
N.S.--Pictou area.. (Stellarton district)	13	58 to 81
N.S.--Pictou area.... (Thorburn district)	4	57 to 62
N.B.--Minto area......... (All districts)	19	65 to 91
B.C.--Telkwa area & Vancouver Island.....	7	71 to 83
Pa. & Ohio--miscellaneous................	18	61 to 76
High Volatile B & C Bituminous		
Alta. & B.C.--miscellaneous..............	6	46 to 63
Sub-bituminous B		
Alta. & B.C.--miscellaneous..............	4	39 to 45
Lignite		
Saskatchewan & Northern Ontario..........	2	54 & 49

TABLE III - Grindability Indices (and Analyses) of Canadian and Other Coals

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur & 2nd B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index b/ (Old)	New	Equivalent Ball-mill Method Index (New) c/
			NOVA SCOTIA - CAPE BRETON ISLAND COLLIERIES									
	Sydney Area (Glace Bay-New Waterford Districts):- High Volatile A Bituminous											
16394	Dominion # 2	Phalen	Domestic Lump	32.6	58.5	(65-154) a/ M1 -138-A 9-S4.	1950	2030	2200	(69)	72	54
16371	" # 2	"	Stoker nut	33.5	56.9	(64-151) M3 -135-A 9-S4.	1900	2010	2300	(65)	66	49
15652	"	....	Bridge slack	32.2	56.8	(65-146) M4 -129-A10-S3.	1920	1980	2215	(70)	81	61
19512	" (metallurgical coal)		Slack	38.1	58.4	(61-148) M3 -143-A 4-S2.	2000	2100	2270	(54)	56	41
19265	" # 9	Harbour	-4" composite	37.4	57.7	(61-152) M2 -143-A 5-S3.	1900	1960	2000	(71)	73	55
19268	" # 9	"	-3/4" (slack)	36.9	57.6	M2 -143-A 5-S3.	1800	1910	1950	(75)	77	58
19270	" # 9	"	-1/8" fines	34.0	58.4	M2 -138-A 7-S4.	1890	2000	2040	(82)	84	64
16400	" #10	Emery	Stoker nut	34.8	55.1	(62-148) M3 -132-A10-S3.	1980	2100	2330	(64)	65	48
14023	" #11	"	-4" composite	33.6	58.2	(64-147) M3 -134-A 8-S3.	1930	2075	2200	(75)	77	58
14025	" #11	"	-1/8" fines	32.6	57.1	M2 -133-A 9-S3.	1980	2080	2100	(79)	84	64
13875	" #12	Harbour	Freshly mined	37.9	57.2	(61-152) M2 -144-A 5-S1.3	1925	2050	2110	(59)	61	45
15073	" #12	"	(Storage pile	37.4	57.1	M2 -141-A 5-S1.6	1930	2030	2170	(68)	72	54
15074	" #12	"	(composite	36.8	57.6	M2 -140-A 5-S1.6	1930	2030	2080	(72)	75	56
15075	" #12	"	(from different	38.5	58.0	M2 -145-A 4-S1.3	1900	1970	2220	(67)	70	52
15076	" #12	"	(parts in coal	37.5	57.7	M2 -142-A 5-S1.6	1910	2050	2100	(70)	74	55
15077	" #12	"	(storage pile	36.9	57.7	M2 -142-A 5-S1.6	1900	2035	2200	(72)	76	57
15138	" #12	"	Bright coal	39.5	57.2	(59-149) M2 -143-A 4-S0.7	2120	2300	2390	(69)	74	55
15072	" #12	"	Dull (splint) coal	41.0	50.5	(56-155) M1 -140-A 8-S1.0	2620	2700	2800	(46)	52	38
13687	" #16	Phalen	-4" composite	34.4	58.5	(64-152) M2 -140-A 7-S3.	1910	2030	2060	(72)	75	56
13689	" #16	"	-1/8" fines	32.5	59.0	M3 -135-A 8-S4.	1940	2040	2170	(77)	80	60
14187	" #24	Emery	-4" composite	34.3	56.2	(63-148) M3 -133-A 9-S3.	1985	2110	2150	(66)	66	49
14190	" #24	"	-3/4" (slack)	33.3	57.2	M3 -132-A 9-S3.	1960	2060	2150	(73)	74	55
14192	" #24	"	-1/8" fines	31.8	57.4	M4 -130-A10-S3.	1980	2040	2120	(74)	75	56
15142	" #24	"	Dull (splint) coal	30.5	49.5	(64-146) M4 -115-A19-S4.	2000	2150	2420	(59)	63	46

a/ This and other values below, indicating B.t.u. per pound to the nearest 100, are on the basis of the coal as received in the laboratory and are for coal that may be partially air-dried during transportation and handling rathern than on the moist (as mined) mineral-matter-free basis as required for Classification by Rank according to A.S.T.M. D 388-38. The values shown, however, do serve to indicate the relative position in the rank classification, and are applicable especially for coals not near the class and group borderlines. For the borderline coals, none other than the B.t.u. values on the moist (capacity moisture) mineral-matter-free basis should be used for detailed classification purposes.

b/ & c/ See footnote p. 22, namely: third to last page of this table.

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur & 2nd B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New b/	Equivalent Ball-mill Method Index (New) c/
19357	Dominion-McNeil Pit	Gardiner	-4" composite	35.7	54.7	(61-146) M3 -131-A 9-S3.	1920	2010	2240	(70)	71	53
19360	" " "	"	-3/4" (slack)	34.5	57.2	M4 -131-A 8-S3.	1950	2050	2240	(65)	67	50
19362	" " "	"	-1/8" fines	28.9	57.7	M3 -122-A13-S4.	1930	2020	2250	(77)	80	60
Sydney Area (Sydney Mines District):- High Volatile A (and B) Bituminous												
14911	Princess	Harbour	+4" lumps			M3 - -A 4-				(59)	58	43
14912	"	"	3 - 4" size			M2 - -A 4-				(62)	62	45
14913	"	"	2 - 3" size			M2 - -A 4-				(62)	63	47
14914	"	"	1½ - 2" size			M2 - -A 4-				(64)	65	48
14915	"	"	1 - 1½" size			M3 - -A 5-				(66)	68	50
14916	"	"	3/4 - 1" size			M3 - -A 5-				(66)	68	50
14917	"	"	1/2 - 3/4" size			M2 - -A 7-				(67)	69	51
14918	"	"	1/4 - 1/2" size			M3 - -A 6-				(68)	70	52
14919	"	"	-1/4" fines			M3 - -A 6-				(70)	73	54
14805	"	"	-4" composite	38.1	56.5	(60-148) M3 -139-A 5-S1.6	1950	2040	2150	(67)	69	51
14808	"	"	-3/4" (slack)	37.0	57.4	M3 -138-A 5-S2.	1890	2060	2300	(74)	76	57
14810	"	"	-1/8" fines	35.4	57.4	M3 -135-A 7-S2.	1830	1930	2060	(76)	79	60
14334	"	"	Domestic lump	39.1	55.9	(59-149) M2 -141-A 5-S3.	1940	2020	2205	(66)	66	49
14847	Florence	"	-4" composite	37.6	57.0	(61-145) M3 -136-A 5-S2.	1970	2040	2150	(70)	72	54
14850	"	"	-3/4" (slack)	37.5	56.9	M4 -136-A 5-S2.	1960	2085	2190	(75)	78	59
14852	"	"	-1/8" fines	34.8	56.0	M4 -130-A 9-S3.	1960	2070	2215	(77)	81	61
18146	Indian Cove (Tompit)	Indian or	-4" composite	35.6	49.4	(60-142) M3 -118-A14-S5+	1890	1990	2090	(69)	70	52
18149	" " "	Greener	-3/4" (slack)	35.3	48.6	M3 -115-A15-S5+	1940	2070	2150	(71)	73	54
18151	" " "	"	-1/8" fines	33.3	45.7	M3 -107-A20-S5+	1920	2040	2120	(71)	73	55
18265	" " (Sullivan)	Crawley or	-4" composite	36.6	53.6	(60-141) M4 -125-A 9-S5.	1920	2030	2260	(61)	61	45
18268	" " "	Frazer	-3/4" (slack)	35.2	53.9	M4 -125-A10-S5.	1900	1970	2070	(60)	61	45
18270	" " "	"	-1/8" fines	31.2	52.6	M3 -115-A16-S5+	1960	2110	2370	(67)	70	52
13842	" "	Indian	Domestic lump	35.4	49.6	M4 -119-A14-S5+	1910	2060	2160	(70)	73	54
18377	Bras d'Or (Colonial #1)	Collins	-4" composite	34.9	55.4	(62-143) M3 -127-A 9-S5+	1900	2100	2320	(68)	68	50
18380	" " "	"	-3/4" (slack)	33.3	55.4	M4 -124-A11-S5+	2040	2160	2400	(65)	66	49
18382	" " "	"	-1/8" fines	31.3	52.5	M3 -115-A16-S5+	1990	2210	2330	(72)	74	55
15337	" " "	"	Run-of-Mine	37.1	54.5	M5 - -A 8-				(73)	74	55
14953	" " "	"	Culm	31.3	52.0	M4 -113-A16-S5+	1960	2110	2200	(83)	88	68

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade designation	Seam	Size or other designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur & 2nd B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	Inverness Area (Inverness-Chimney Corner and Port Hood districts):- High Volatile C (and B) Bituminous											
17829	Inverness #1	Seven Ft.	-4" composite	38.6	47.6	(57-132) M5 -112-A13-S5+	1900	2020	2040	(62)	62	46
17832	" #1	" "	-3/4" (slack)	38.5	47.7	M5 -113-A13-S5+	1930	2020	2075	(59)	60	44
17834	" #1	" "	-1/8" (fines)	34.2	46.6	M5 -104-A18-S5+	1980	2100	2200	(61)	62	46
14333	" #1	" "	Domestic lump	39.8	47.3	(56-131) M6 -112-A12-S5+	2005	2100	2240	(59)	59	43
17925	" #4	Thirteen"	-4" composite	38.4	49.6	(58-126) M8 -109-A11-S5+	2100	2260	2450	(61)	62	46
17928	" #4	" "	-3/4" (slack)	38.1	48.8	M7 -109-A12-S5+	1900	2000	2200	(66)	66	49
17930	" #4	" "	-1/8" fines	33.7	46.1	M6 -101-A19-S5+	1890	1915	2010	(68)	69	51
19425	St. Rose		-4" composite	36.8	50.5	(59-134) M5 -115-A12-S5+	1950	2050	2090	(63)	65	47
19428	"		-3/4" (slack)	37.0	50.3	M5 -115-A12-S5+	1830	1950	2030	(65)	68	50
19430	"		-1/8" fines	36.4	47.7	M5 -108-A15-S5+	1830	1900	1970	(68)	71	53
18011	Port Hood	Main	-4" composite	35.3	49.4	(60-135) M4 -113-A15-S5+	1890	1965	2000	(59)	62	46
18014	" "	"	-3/4" (slack)	35.5	49.3	M4 -112-A14-S5+	1880	1920	2000	(60)	61	45
18016	" "	"	-1/8" fines	36.0	47.6	M4 -110-A16-S5+	1840	1900	1950	(60)	61	45
19522	" "	"	Domestic lump	35.3	46.1	(59-132) M5 -105-A18-S5+	1880	2000	2080	(63)	65	47
	NOVA SCOTIA - MAINLAND COLLIERIES											
	Springhill Area (Cumberland County):- High Volatile A Bituminous.											
15217	Springhill #2	No. 1	-4" composite	31.9	58.7	(66-150) M2 -134-A 9-S3.	2030	2130	2180	(82)	85	65
15220	" #2	"	-3/4" (slack)	31.8	55.8	M1 -130-A12-S3.	1950	2040	2120	(84)	89	69
15222	" #2	"	-1/8" fines	32.1	57.6	M2 -133-A10-S2.	1970	2080	2200	(85)	91	71
15165	" #2	No. 2	-4" composite	30.7	61.1	(67-152) M2 -138-A 8-S1.3	2040	2160	2210	(83)	86	66
15168	" #2	"	-3/4" (slack)	31.0	60.3	M1 -136-A 9-S1.3	2060	2140	2200	(93)	103	83
15170	" #2	"	-1/8" fines	31.3	59.6	M2 -136-A 9-S1.3	2040	2160	2250	(94)	100	80
13948	" #2	"	Domestic lump	31.1	59.0	(66-152) M2 -135-A10-S2.	2100	2230	2365	(82)	84	64
15590	" #6	No. 6	-4" composite	32.7	55.2	(64-143) M3 -125-A12-S2.	2020	2150	2210	(71)	71	53
15593	" #6	"	-3/4" (slack)	30.9	52.6	M3 -116-A16-S3.	2030	2120	2210	(70)	71	53
15595	" #6	"	-1/8" fines	29.9	52.1	M3 -113-A17-S3.	2060	2110	2260	(70)	70	52
15519	" #7	No. 7	-4" composite	30.6	58.4	(67-143) M2 -130-A11-S1.6	2070	2190	2400	(75)	76	57
15522	" #7	"	-3/4" (slack)	30.7	55.4	M2 -126-A14-S2.	2055	2190	2380	(80)	82	62
15524	" #7	"	-1/8" fines	30.8	56.7	M2 -128-A12-S2.	2085	2215	2350	(88)	90	70

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade designation	Seam	Size or other designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur & 2nd B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	River Hebert Area (Cumberland County):- High Volatile A (and B) Bituminous											
18441	Strathcona #1		-4" composite	35.3	50.3	(60-145) M2 -122-A14-S5+	1950	2010	2120	(64)	66	49
19444	" #1		-3/4" (slack)	35.6	48.8	M2 -120-A15-S5	1950	2010	2110	(66)	68	50
18446	" #1		-1/8" fines	39.8	46.9	M2 -112-A20-S5	2000	2080	2210	(70)	72	54
18560	Victoria #4	Joggins Bench	-4" composite	34.9	45.3	(58-147) M2 -115-A19-S5+	1940	2040	2150	(71)	76	57
18563	" #4	" "	-3/4" (slack)	33.7	44.5	M2 -110-A20+-S5+	1940	2090	2200	(72)	74	55
18565	" #4	" "	-1/8" fines	32.8	41.8	M2 -105-A20+-S5	2030	2150	2200	(71)	74	55
12277	" #4	" "	Domestic lump	31.4	37.8	M3 - -A20+-S5	2300	2360	2450	(72)	75	56
18648	Maple Leaf #4	" "	-4" composite	34.2	45.9	(59-145) M2 -113-A19-S5	1920	2010	2100	(72)	75	56
18651	" " #4	" "	-3/4" (slack)	33.6	46.2	M2 -113-A20-S5	2010	2060	2140	(71)	74	55
18653	" " #4	" "	-1/8" fines	32.8	42.3	M2 -105-A20+-S5	1990	2100	2250	(73)	78	59
	Pictou Area (Westville District):- Medium Volatile Bituminous											
	Intercolonial - Drummond coals											
18853	Drummond #2		-4" composite	23.5	54.0	(72-152) M1 -114-A20+-S1.6	2480	2570	2620	(73)	78	59
18856	" #2		-3/4" (slack)	24.0	55.5	M1 -116-A20+-S1.6	2400	2450	2500	(71)	77	58
18858	" #2		-1/8" fines	24.4	55.8	M1 -118-A20-S1.4	2240	2340	2450	(74)	77	58
18907	" #1 & #5		-4" composite	26.6	59.5	(70-151) M2 -128-A14-S1.0	2240	2300	2400	(79)	84	64
18910	" #1 & #5		-3/4" (slack)	26.5	57.4	M2 -124-A16-S1.3	2270	2350	2420	(79)	82	62
18912	" #1 & #5		-1/8" fines	26.1	55.9	M2 -121-A18-S1.3	2250	2340	2400	(77)	80	60
13922	" #1 & #2		Domestic lump	25.4	57.4	(71-152) M2 -124-A17-S1.0	2900	2430	2550	(80)	83	63

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other Designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur & 2nd B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	Hardgrove Machine Method Index New	Equivalent Ball-mill Method Index (New)
Pictou Area (Stellarton District):- High Volatile A Bituminous												
19002	Albion (Acadia)	Third	-4" composite	28.6	58.8	(68-150) M2 -130-A12-S1.3	2420	2510	2600	(64)	66	49
19005	" "	"	-3/4" (slack)	29.0	58.6	M2 -130-A12-S1.6	2210	2380	2500	(65)	68	50
19007	" "	"	-1/8" (fines)	27.8	60.0	M2 -130-A12-S1.6	2240	2310	2470	(72)	75	56
19073	Albion-Allen & #7	Cage	-4" composite	30.0	55.9	(66-147) M2-124-A14-S1.6	2210	2460	2590	(56)	58	42
19076	" " "	"	-3/4" (slack)	30.2	56.2	M2 -125-A13-S1.6	2200	2350	2450	(58)	61	45
19078	" " "	"	-1/8" (fines)	29.6	56.7	M2 -124-A13-S1.6	2150	2220	2300	(59)	62	46
18947	Allan (Acadia)	Foord	-4" composite	27.5	55.6	(68-154) M2 -126-A17-S0.7	2520	2630	2740	(72)	76	57
18950	" "	"	-3/4" (slack)	27.8	56.9	M2 -127-A15-S1.0	2520	2620	2720	(74)	78	59
18952	" "	"	-1/8" (fines)	27.7	58.9	M2 -131-A13-S1.0	2270	2470	2560	(87)	91	77
13886	" "	6 Ft. Vale	Domestic lump	28.9	54.0	M2 -126-A17-S1.0	2270	2530	2570	(75)	78	59
19177	" "	4 Ft. Vale	-4" composite	29.6	55.6	(67-152) M1 -127-A15-S1.6	2150	2250	2320	(78)	81	61
19180	" "	"	-3/4" (slack)	29.8	57.0	M1 -130-A13-S1.3	2200	2300	2430	(78)	81	61
19182	" "	"	-1/8" (fines)	30.1	57.4	M1 -130-A12-S1.3	2160	2250	2280	(79)	81	61
19060	" "		Dull (splint) coal	27.7	40.5	M2 - 95-A20+-S1.3	2180	2250	2400	(62)	67	50
19061	Allan-Albion		Dull (splint) coal	26.8	46.7	M2 -105-A20+-S1.6	2035	2440	2550	(64)	68	50
19118	McGregor (Acadi)	McGregor	-4" composite	27.8	56.3	(68-150) M2 -124-A16-S1.3	2650	2745	2800	(60)	63	46
19121	" "	"	-3/4" (slack)	27.8	57.6	M2 -125-A16-S1.3	2500	2605	2690	(65)	67	50
19123	" "	"	-1/8" (fines)	27.6	58.0	M2 -126-A14-S1.3	2420	2580	2620	(60)	63	46
19232	" "	Fleming	-4" composite	27.8	58.3	(69-151) M2 -128-A14-S1.3	2260	2550	2650	(69)	72	54
19235	" "	"	-3/4" (slack)	27.4	58.9	M2 -128-A14-S1.3	2260	2470	2510	(71)	73	55
19237	" "	"	-1/8" (fines)	27.8	59.2	M2 -127-A14-S1.0	2330	2380	2490	(71)	74	55
Pictou Area (Thorburn District):- High Volatile A (and B) Bituminous												
18778	Acadia #3 & #8	6 Ft. Vale	-4" composite	29.0	51.7	(66-146) M3 -115-A19-S0.7	2450	2640	2720	(57)	60	44
18781	" "	"	-3/4" (slack)	27.5	51.7	M3 -112-A20+-S1.0	2560	2640	2740	(55)	57	42
18783	" "	"	-1/8" (fines)	24.7	52.9	M2 -109-A20+-S1.3	2320	2400	2460	(64)	67	50
18715	Milford (Greenwood)		-4" composite	29.8	53.6	(66-143) M4 -118-A16-S1.0	2500	2750	2850	(60)	62	46
18718	" "		-3/4" (slack)	28.2	53.9	M3 -116-A17-S1.3	2480	2600	2785	(57)	59	43
18220	" "		-1/8" (fines)	26.1	53.9	M3 -112-A19-S1.3	2200	2300	2360	(64)	67	50

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade designation	Seam	Size or other designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur and B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	NEW BRUNSWICK											
	Minto Area (North Minto, South Minto, Newcastle Bridge and Chipman Districts):- High Volatile A Bituminous											
15799	Avon-Winterport		-4" composite	32.5	51.2	(63-152) M1 -124-A16 -S5+	1920	1980	2000	(76)	78	598
15802	" "		-3/4" (slack)	32.3	49.5	M1 -118-A18 -S5+	1955	2015	2030	(87)	91	71
15804	" "		-1/8" (fines)	31.4	48.2	M2 -114-A20 -S5+	1885	1990	2010	(95)	98	78
19689	Avon-Shafts 26 & 28		-4" composite	31.0	51.7	(64-152) M1 -122-A17 -S5+	1920	2000	2050	(77)	80	60
19692	" "		-3/4" (slack)	30.8	50.3	M2 -118-A18 -S5+	1960	2040	2070	(72)	75	56
19694	" "		-1/8" (fines)	30.1	49.5	M1 -115-A20 -S5+	1915	2020	2060	(82)	86	66
17621	Avon coal (marketed for pulverized fuel)					M1 -122-A18 -S5+				(84)	86	66
19551	Benton-Evans (Rothwell)		-4" composite	32.6	51.9	(63-153) M1 -126-A15 -S5+	1940	2040	2060	(70)	73	55
19554	" " "		-3/4" (slack)	32.4	50.8	M1 -122-A17 -S5+	1960	2050	2090	(74)	76	57
19556	" " "		-1/8" (fines)	31.0	48.1	M1 -115-A20+-S5+	1900	2030	2100	(76)	79	60
19608	Minto-Tweedie C1,C2,C3		-4" composite	31.8	52.8	(64-152) M1 -125-A15 -S5+	1955	2050	2075	(33)	74	55
19611	" " "		-3/4" (slack)	30.6	50.7	M2 -117-A18 -S5+	2000	2050	2070	(76)	79	60
19613	" " "		-1/8" (fines)	29.8	48.7	M2 -111-A20+-S5+	1960	2075	2110	(80)	83	63
19485	Minto-West Slope (P & C S)		-4" composite	30.9	50.0	(64-156) M1 -122-A19 -S5+	1900	2060	2090	(69)	70	52
19488	" " " "		-3/4" (slack)	30.4	48.9	M1 -119-A20 -S5+	1880	2000	2060	(73)	76	57
19490	" " " "		-1/8" (fines)	27.1	42.0	M1 -101-A20+-S5+	2040	2130	2220	(83)	86	66
15683	Minto- " "	(R.O.M.)	-4" composite	32.2	52.9	(64-153) M1 -127-A15 -S5+	1890	1940	1960	(74)	77	58
15686	" " "	"	-3/4" (slack)	31.7	50.8	M1 -123-A17 -S5+	1895	1960	1980	(74)	77	58
15688	" " "	"	-1/8" (fines)	28.3	45.4	M1 -109-A20+-S5+	1950	2040	2350	(79)	81	61
12265	Minto coal (marketed for pulverized fuel)			32.0	54.8	M2 - -A13 -S5+	2000	2180	2300	(74)	79	60
14418	Miramichi coal (as marketed)		R.O.M.	31.3	51.8	M1 - -A17 -S5+	1900	2000	2040	(79)	82	62
14419	" " "		Slack	30.9	47.8	M4 - -A20+-S5+	1930	2010	2045	(83)	86	66
13973	Welton & Henderson		Domestic lump	31.1	49.6	(64-155) M1 -121-A19 -S5+	1950	2010	2140	(70)	72	54
19750	" "	Kelley	-4" composite	33.3	53.6	(63-154) M1 -131-A13 -S5+	1900	2040	2070	(64)	65	48
19753	" "	"	-3/4" (slack)	33.4	52.5	M1 -130-A14 -S5+	1990	2040	2080	(69)	70	52
19755	" "	"	-1/8" (fines)	31.6	50.0	M1 -120-A18 -S5+	1940	2060	2100	(69)	71	53
19312	Burpee (Myles) Stripping		R.O.M.	34.4	59.0	(64-144) M3 -133-A 6 -S3	2270	2430	2610	(85)	82	65

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other Designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur and B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	ALBERTA											
	Luscar, Mountain Park and Crowsnest Districts:- Medium Volatile and High Volatile A Bituminous											
17455	Luscar (Locomotive fuel)		-4" composite	21.7	65.2	(76-154) M1 -132-A13-S0.7	2280	2375	2420	(85)	88	68
17458	" " "		-3/4" (slack)	21.0	66.0	M1 -132-A13-S0.7	2480	2680	2780	(96)	98	78
17460	" " "		-1/8" (fines)	21.0	65.8	M1 -132-A13-S0.7	2650	2850	2850+	(93)	96	76
16279	Mountain Park		Domestic lump	28.8	62.7	(69-152) M1 -138-A 8-S0.7	2280	2365	2450	(74)	75	56
15297	Greenhill		Slack lump	23.8	65.0	M1 - -A10-	2700	2870	2870	(94)	97	77
	Prairie Creek, Coalspur, and Saunders Areas:- High Volatile B and C Bituminous											
15280	Hinton		Domestic lump	35.9	47.6	(58-134) M7 -112-A15-S0.7	2205	2360	2440	(53)	55	40
16274	Coal Valley		Domestic lump	34.4	47.0	(59-122) M8 - 99-A17-S0.7	2100	2240	2375	(55)	55	40
18197	Alexo		Lump	35.0	57.3	M7 - -A 8-S0.7				(53)	52	38
16278	Lakeside		Domestic lump	37.2	48.0	(57-121) M9 -103-A13-S0.7	2055	2160	2200	(45)	46	33
	Drumheller Area:- Sub-bituminous B											
16277	Rosedale		Domestic lump	38.1	52.2	(58-107) M17- 98-A 8-S0.7	2235	2330	2430	(39)	40	28
16596	"		Domestic egg	37.0	50.4	(58-) M16- 94-A10-S0.7	2050	2150	2320	(39)	39	28
	BRITISH COLUMBIA											
	Crowsnest and Telkwa Areas:- Medium and High Volatile A Bituminous											
7222	Michel		R.O.M.	28.4	65.4	(70-153) M2 -143-A 6-S0.7	1960	2030	2350	(96)	102	82
8920	Corbin		Birdseye	22.5	59.8	M5 -116-A17-S0.7	2600	2700+	2700+	(92)	95	75
6768	Telkwa (Broughton & McNeil)		Lump	31.6	55.3	(65-144) M5 -124-A12-S1.3	2150	2170	2280	(71)	74	55
14046	"		Domestic lump	28.4	59.9	(69-146) M4 -128-A11-S1.0	2300	2390	2520	(71)	71	53
	Vancouver Island and Nicola Areas:- High Volatile A and B Bituminous											
7122	Comox (Dunsmuir)		Washed pea	31.1	53.9	M5 -122-A14-S1.6	2435	2460	2500	(74)	76	57
6722	Wellington #5 Mine		Washed slack	36.7	44.5	M8 -111-A17-S1.0	2070	2145	2320	(78)	81	61
6721	Reserve Mine - Nanaimo		Washed slack	38.4	46.9	M7 -117-A14-S1.0	2045	2225	2240	(75)	77	58
14052	" " "		Domestic lump	40.7	46.1	(54-142) M3 -122-A13-S1.6	2150	2180	2210	(75)	77	58
7042	Cassidy (Granby)		Washed slack	38.2	48.9	M5 -123-A12-S0.7	2270	2310	2340	(81)	83	63
6659	Coalmont (Nicola)		R.O.M.	36.8	49.1	(58-131) M8 -112-A13-S0.7	2080	2240	2460	(61)	63	46
16565	Middlesboro (Nicola)		R.O.M.	39.8	48.3	(55-130) M9 -114-A11-S0.7	2475	2590	2590+	(54)	53	38

b/ These are the (Old) and New indices obtained by the original and the revised calculation formulas respectively.
c/ The (revised) Hardgrove index was used to obtain the equivalent Ball-mill index by means of conversion table.

TABLE III (Cont.)

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other Designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur, and B.t.u.-figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	MISCELLANEOUS CANADIAN COALS											
6470	Tulameen B.C.	Sub-bit. B	R.o.m.	36.6	52.5	(60-104) M21- 94-A 9-S0.7	1995	2120	2200	(38)	39	28
6469	Pleasant Valley B.C.	"	Lump	34.4	48.1	(60- 96) M24- 82-A13-S0.7	1995	2095	2260	(45)	45	32
16275	Bienfait, Sask.	Lignite	Domestic lump	40.3	51.6	(57- 81) M33- 76-A 5-S0.7	2315	2420	2480	(54)	54	39
19524	Onakawana, Ont.	"	Air-dried lump	46.3	43.8	M21- 81-A 8-S1.0	2040	2180	2260	(48)	49	35
	AMERICAN, BRITISH AND OTHER (EUROPEAN) ANTHRACITES											
3301-5	Pennsylvania--Schuylkill County			3.0	87.6	(98-144) M4 -130-A 9-S0.7				(38)	32	27
3301-4	" --Northumberland County			6.5	83.9	(94-151) M3 -135-A 9-S1.0				(52)	52	38
15314	"			6.5	83.6	(94-148) M3 -132-A10-S1.0	2840	2840+		(28)	29	20
13500	"			5.4	85.2	(95-148) M3 -132-A 9-S1.0	2710	2865	2910	(29)	31	22
15316	French Indo-China anthracite			4.2	90.2	(96-140) M4 -131-A 5-S0.7	2040	2210	2350	(34)	35	25
17599	" " "		Stove size	3.0	92.3	(97-139) M4 -132-A 4-S0.7	2000	2170	2440	(34)	34	24
17550	Russian anthracite		Egg size	3.4	93.1	(97-140) M4 -135-A 4-S1.3	1920	2075	2280	(34)	34	24
17551	" "		Stove size	3.7	92.0	(97-141) M4 -135-A 4-S1.6	1930	2080	2240	(34)	34	24
16281	Welsh anthracite		Cobbles size	8.1	88.9	M1 - -A 4-	2200	2450	2650	(48)	48	34
16330	" "		Cobbles size	8.5	85.0	(92-149) M2 -139-A 6-S1.3	2040	2215	2540	(50)	50	36
16375	" "		Cobbles size	7.2	89.2	M2 - -A 4-	2260	2340	2500	(51)	50	36
13975	" "		Cobbles size	8.0	87.5	(92-151) M2 -144-A 4-S1.0	2280	2400	2700	(58)	58	42
14361	" "		Nut size	8.1	87.5	(92-151) M2 -144-A 4-S1.0	2180	2370	2515	(52)	52	38
15277	" "		Buckwheat size	8.3	87.1	(92-151) M2 -143-A 4-S1.0	2250	2410	2540	(55)	54	39
15315	" "		Buckwheat size	8.9	86.6	(91-152) M2 -145-A 4-S1.0	2100	2385	2535	(54)	54	39
16143	" "		Buckwheat size	9.9	83.8	(90-) M3 - -A 6-				(55)	54	39
16376	" "		Buckwheat size	9.7	84.4	( ) M1 - -A 6-	2070	2210	2575	(56)	56	41
16141	Westphalian anthracite		Cobbles size	9.8	85.2	(90-) M2 - -A 5-				(55)	54	39
16373	" "		Stove size	9.6	85.3	(90-153) M1 -145-A 5-S1.0	2050	2170	2460	(55)	54	39
16374	" "		Buckwheat size	10.4	83.8	(90-154) M1 -144-A 6-S1.3	2030	2150	2590	(56)	55	40
16142	" "		Buckwheat size	9.1	85.9	(91-) M4 - -A 5-				(63)	62	46
	MISCELLANEOUS											
19515	Petroleum coke		Lump	16.8	81.2	M2 -152-A 4-S3.	2600	2610	2615		128	

TABLE III (Concl.)

Laboratory No.	Source and Description of Sample: Mine or Trade Designation	Seam	Size or other Designation	Dry Basis: Volatile Matter %	Dry Basis: Fixed Carbon %	Rank and Grade Classification (Key to symbols page 4) Moisture, Ash, Sulphur and B.t.u. figures are on the coal as sampled basis	Fusion Point of Ash (F.P.A.): Initial Temp. °F.	Softening Temp. °F.	Fluid Temp. °F.	Grindability: Hardgrove Machine Method Index (Old)	New	Equivalent Ball-mill Method Index (New)
	MISCELLANEOUS AMERICAN BITUMINOUS COALS											
	Low and Medium Volatile Bituminous											
3301-1	Pocahontas--McDowell Co. W.Va.--No. 3 Bed			18.5	76.1	(81-157) M1 -147-A 5-S0.7				(103)	107	87
19514	"	Beckley Seam		18.1	76.2	(81-152) M3 -143-A 5-S1.0	2850+	2850+		(92)	100	80
16202	"	Olga Mine	Domestic "Egg"	15.8	73.3	(83-156) M1 -138-A11-S0.7	2230	2300	2350	(94)	98	78
14239	Rockhill		Domestic lump	16.1	74.4	(83-159) M1 -142-A 9-S1.6	2730	2860	2860+	(98)	98	78
16214	Royal			25.1	67.1	(74-156) M1 -142-A 8-S1.6	2610	2690	2750	(98)	101	81
19513	Kent			29.1	64.1	(69-150) M4 -139-A 6-S1.0	2500	2630	2740	(74)	76	57
	High Volatile A Bituminous											
19511	Banning			33.2	59.8	(65-149) M3 -136-A 7-S1.0	2580	2700	2850+	(60)	61	45
14725	Hutchinson		Composite	33.8	59.0	(64-154) M2 -142-A 7-S1.0	2800	2970	3000+	(71)	76	57
14725a	"		+4" lumps			M2 - -A 6-				(64)	67	50
14725b	"		3 - 4" lumps			M2 - -A 6-				(65)	67	50
14725c	"		2 - 3" lumps			M2 - -A 7-				(65)	67	50
14725d	"		1½ - 2" lumps			M2 - -A 7-				(67)	69	51
14725e	"		1 - 1½" lumps			M2 - -A 7-				(70)	72	54
14725f	"		3/4 - 1" lumps			M2 - -A 7-				(73)	76	57
14725g	"		1/2 - 3/4"			M2 - -A 7-				(73)	76	57
14725h	"		1/4 - 1/2"			M2 - -A 6-				(74)	76	57
14725i	"		-1/4" fines			M2 - -A 7-				(75)	77	58
	Ohio (Rail & River) Coals - Belmont County											
14056	Rail & River	Pittsburgh #8	Domestic lump	41.5	50.2	(55-144) M3 -131-A 8-S4.	1900	2020	2040	(67)	67	50
16505	" " #3 Mine	"	-4" composite	41.0	49.9	(56-147) M2 -131-A 9-S5.	1970	2055	2110	(68)	70	52
16508	" " "	"	-3/4" (slack)	39.1	50.3	M2 -129-A10-S5.	2000	2050	2100	(67)	68	50
16510	" " "	"	-1/8" (fines)	37.4	51.2	M2 -128-A11-S5.	1980	2045	2110	(71)	72	54
16459	" " #4 Mine	"	-4" composite	40.6	51.4	(57-146) M2 -133-A 8-S4.	1860	2070	2160	(67)	68	50
16462	" " "	"	-3/4" (slack)	39.1	51.7	M2 -131-A 9-S4.	1990	2070	2120	(71)	73	55
16464	" " "	"	-1/8" (fines)	37.9	51.7	M2 -128-A10-S4.	1960	2060	2160	(73)	68	57
16560	" " #6 Mine	"	-4" composite	40.1	50.6	(56-147) M2 -133-A 8-S4.	1940	2080	2150	(65)	66	49
16563	" " "	"	-3/4" (slack)	40.0	50.7	M2 -130-A 9-S4.	1960	2080	2150	(72)	74	55
16505	" " "	"	-1/8" (fines)	37.3	51.6	M2 -127-A11-S4.	1920	2030	2160	(69)	69	51

Appendix

Approximate Conversions of Grindability Indices by the Hardgrove-Machine Method to Ball-Mill Method Indices

Hardgrove Grindability Index	Equivalent Ball-mill Grindability Index	Hardgrove Grindability Index	Equivalent Ball-mill Grindability Index
15	(10.6) - 11[a]/	68	(50.4) - 50[a]/
16	(11.1) - 11	69	(51.3) - 51
17	(11.9) - 12	70	(52.0) - 52
18	(12.6) - 13	71	(52.9) - 53
19	(13.2) - 13	72	(53.8) - 54
20	(13.9) - 14	73	(54.6) - 55
21	(14.5) - 15	74	(55.4) - 55
22	(15.2) - 15	75	(56.3) - 56
23	(16.0) - 16	76	(57.2) - 57
24	(16.6) - 17	77	(58.0) - 58
25	(17.3) - 17	78	(58.9) - 59
26	(18.0) - 18	79	(59.7) - 60
27	(18.7) - 19	80	(60.4) - 60
28	(19.5) - 20	81	(61.4) - 61
29	(20.2) - 20	82	(62.4) - 62
30	(20.9) - 21	83	(63.4) - 63
31	(21.6) - 22	84	(64.4) - 64
32	(22.4) - 22	85	(65.3) - 65
33	(23.1) - 23	86	(66.3) - 66
34	(23.9) - 24	87	(67.3) - 67
35	(24.6) - 25	88	(68.2) - 68
36	(25.3) - 25	89	(69.2) - 69
37	(26.0) - 26	90	(70.1) - 70
38	(26.8) - 27	91	(71.0) - 71
39	(27.5) - 28	92	(72.0) - 72
40	(28.2) - 28	93	(73.0) - 73
41	(29.4) - 29	94	(74.0) - 74
42	(29.8) - 30	95	(75.0) - 75
43	(30.5) - 31	96	(76.0) - 76
44	(31.3) - 31	97	(77.0) - 77
45	(32.1) - 32	98	(78.0) - 78
46	(32.9) - 33	99	(79.0) - 79
47	(33.7) - 34	100	(80.0) - 80
48	(34.5) - 34	101	(81.0) - 81
49	(35.2) - 35	102	(82.0) - 82
50	(35.9) - 36	103	(83.0) - 83
51	(36.7) - 37	104	(84.0) - 84
52	(37.5) - 38	105	(85.0) - 85
53	(38.4) - 38	106	(86.0) - 86
54	(39.2) - 39	107	(87.0) - 87
55	(40.0) - 40	108	(88.0) - 88
56	(40.8) - 41	109	(89.0) - 89
57	(41.7) - 42	110	(90.0) - 90
58	(42.4) - 42	111	(91.0) - 91
59	(43.1) - 43	112	(92.0) - 92
60	(44.0) - 44	113	(93.0) - 93
61	(44.8) - 45	114	(94.0) - 94
62	(45.6) - 46	115	(95.0) - 95
63	(46.5) - 46	116	(96.0) - 96
64	(47.2) - 47	117	(97.0) - 97
65	(48.0) - 48	118	(98.0) - 98
66	(48.9) - 49	119	(99.0) - 99
67	(49.7) - 50	120	(100.0) - 100

a/ These are the equivalent Ball-mill indices to the nearest whole number.

Note: The indices underlined are those given in Appendix of D 409-37T, A.S.T.M.