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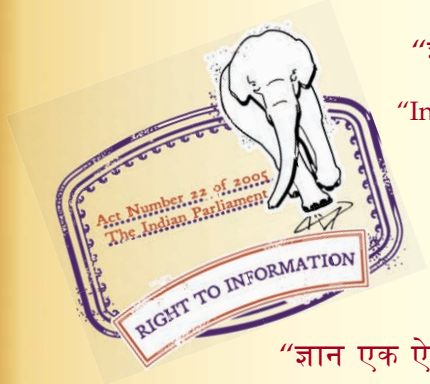

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"Knowledge is such a treasure which cannot be stolen"

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IS : 770 – 1977
(Superseding IS : 5018 - 1968)
(Reaffirmed 2001)

Indian Standard

CLASSIFICATION AND CODIFICATION OF INDIAN COALS AND LIGNITES

(Second Revision)

Fourth Reprint AUGUST 2007
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BUREAU OF INDIAN STANDARDS
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Gr 5 *October* 1978

AMENDMENT NO. 1 JANUARY 1985

TO

IS:770-1977 CLASSIFICATION AND CODIFICATION OF INDIAN COALS AND LIGNITES

(Second Revision)

(*Page 6, clause 3.5.2, second sentence*) - Substitute the following for the existing sentence:

'For Gray-King (LT) assay the method for preparation of sample as given in 7.3 of IS:1353-1959‡ shall be followed.'

(PCDC 7)

Indian Standard

CLASSIFICATION AND CODIFICATION OF INDIAN COALS AND LIGNITES

(Second Revision)

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Indian Standard

CLASSIFICATION AND CODIFICATION OF INDIAN COALS AND LIGNITES

(Second Revision)

0. FOREWORD

0.1 This Indian Standard (Second Revision) was adopted by the Indian Standards Institution on 26 December 1977, after the draft finalized by the Solid Mineral Fuels Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

0.2 With the issue of IS : 770-1964* followed by IS : 5018-1968† it had been felt that the two standards, though complementary to each other, were somewhat overlapping and repetitive in nature and that there was scope for merging and extending the two into a more meaningful and comprehensive standard, while retaining and reinforcing the scientific and pragmatic features of both. The present revision thus replaces IS : 5018-1968†.

0.3 The object of this standard is to provide as much scientific and technological information as possible about the identification and classification of Indian coals and lignites for various industrial uses, such as combustion, carbonization, gasification and hydrogenation. Selection of coal to suit the needs of a particular industry depends upon:

a) the nature, rank and behaviour of the combustible matter (the organic part of coal);

b) the nature and quantity of impurities present in coal (the mineral matter and its composition); and

c) the size-consist of coal and other physical and chemical characteristics.

This standard is, however, primarily concerned with the first of the three main factors, which essentially govern the intrinsic physical and chemical properties of coal and consequently, predetermine its industrial behaviour, provided that other extraneous factors, such as mineral matter, its composition and behaviour as well as presence of undue proportions of sulphur,

*General classification of coal (*revised*).
†Classification of hard coals by type.

phosphorus, etc, do not act against the purpose of the coal for a particular end use. It should be, therefore, clearly understood that such important characteristics as the nature and amount of mineral matter, ash fusion temperature, grindability index, sulphur and phosphorus contents as well as the size-consist of coal need also to be taken into consideration in finally selecting a coal for a particular commercial use.

0.4 This standard while incorporating some features of IS: 770-1964* is also based on the framework of IS: 5018-1968†, and is now extended to include the classification of brown coals and lignites as well. In this revised standard, three basic parameters, that is, calorific value, volatile matter and Gray-King coke type, which had been adopted in IS : 5018-1968†, have been retained to characterize and specify the nature and behaviour of the essential part of coal, that is, the coal substance. But to make the classification more precise and discriminatory, between caking/coking coals on the one hand and non-caking coals on the other, two supplementary parameters, that is, maximum thickness of plastic layer (MTPL) and air-equilibrated moisture, at 60 percent relative humidity and 40°C, have also been adopted.

0.5 While Gray-King coke type indicates the caking property as well as the likely cokeability of a caking coal, the plastic properties, as determined by plastometric tests provide additional information on the nature and behaviour of the caking coal and thus reinforces the information derived from the Gray-King coke type determination. Of the different plastic properties, the maximum thickness of plastic layer (MTPL) as determined by Sapozhnikov Plastometric test, is an important property of caking/coking coals and when such values are integrated with coke type and volatile matter, they give a more definite information on the cokeability of a caking/coking coal.

0.6 Non-caking coals cannot be characterized and differentiated by coke type and hence the supplementary parameter of moisture (at 60 percent relative humidity and 40°C) has been adopted, so as to increase the scope of the present standard in classifying and demarcating different types of non-caking coals, including brown coals and lignites.

0.7 The parameter ranges of calorific value, earlier adopted in IS : 5018-1968†, have been suitably modified so as to include brown coals and lignites and to broadly demarcate the coals into their characteristic groups, consistent with their other properties.

0.8 Although two supplementary parameters, that is, MTPL and moisture have been introduced, the classification by the three digit code number in

*General classification of coal (*revised*).
†Classification of hard coals by type.

terms of calorific value, volatile matter and coke type, as was originally adopted in IS : 5018-1968*, would normally remain operative in the present standard as well. But, wherever necessary, this 3-digit classification may be extended to 4-digits in terms of either of the two supplementary parameters, that is, MTPL in case of caking coals, and moisture for non-caking coals.

0.9 This standard is based on the results of investigations carried out and data collected by Central Fuel Research Institute, Jealgora. In the formulation of this standard assistance has also been derived from Publications No. 1956. 11, E.4, E/ECE/247E/ECE/COAL/110 'International classification of hard coals by type', issued by the United Nations.

1. SCOPE

1.1 This standard specifies the classification and codification by type of Indian coals, ranging from lignites to anthracites.

1.2 This standard also includes information on the general characteristics and utilization of coals and lignites, with relation to their code numbers.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 3810 (Part I)-1978† and IS : 3810 (Part II)-1978‡ shall apply (*see also* Appendix A).

3. CLASSIFICATION PARAMETERS

3.0 General — This classification is based on three basic parameters and two supplementary parameters as follows:

a) *Basic Parameters* — comprising the following:
   1) Gross calorific value,
   2) Volatile matter, and
   3) Gray-King (LT) coke type.

b) *Supplementary Parameters* — comprising the following:
   1) Maximum thickness of plastic layer (MTPL), and
   2) Air-equilibrated moisture at 60 percent relative humidity and 40°C.

3.0.1 The basis of expression of these parameters shall be as given in **3.1** to **3.5.3.**

---

*Classification of hard coals by type.

†Glossary of terms relating to solid mineral fuels: Part I Terms relating to coal and its preparation (*first revision*).

‡Glossary of terms relating to solid mineral fuels: Part II Terms relating to coal sampling and analysis (*first revision*).

3.1 The gross calorific value shall be on pure coal substance basis, that is, dry mineral matter-free basis, and shall be determined in accordance with IS : 1350 (Part II)-1970*.

3.2 The volatile matter shall be expressed on pure coal substance basis, and shall be determined in accordance with IS : 1350 (Part I)-1969†.

3.3 The Gray-King (LT) assay shall be determined in accordance with IS : 1353-1959‡. When coals have less than 17 percent ash, G-K coke type shall be assessed on the coals as received, but where the ash content exceeds 17 percent, the coals shall first be prepared to bring down the ash content below 17 percent and then only they shall be used for the test. This test may be considered redundant for non-coking coals.

3.4 Moisture on 60 percent relative humidity at 40°C basis shall be determined in accordance with **6.7** of IS : 1350 (Part I)-1969†, and shall be expressed as parts per 100 parts of pure coal substance (M_u) for its use as a supplementary parameter in the present standard.

3.5 Maximum thickness of plastic layer (MTPL) shall be determined according to Sapozhnikov Plastometric test, a brief outline of which is given in Appendix B.

3.5.1 The characteristic result of the MTPL test is the maximum thickness of plastic layer in mm formed under specified conditions of carbonization.

3.5.2 The MTPL test also shall be carried out on coal having ash content less than 17 percent; and where ash content exceeds 17 percent, coal shall be prepared for the test as prescribed in **3.3**. For the MTPL test and Gray-King (LT) assay the method for preparation of sample as given in **7.3** of IS : 1353-1959‡ shall be followed.

3.5.3 The MTPL test shall be determined only in case of those coals which give G-K (LT) coke of type ' C ' or better.

4. CODE NUMBERS

4.0 General — The code numbers are suitably arranged in Table 1 to form the code classification system.

4.1 Each type of coal shall be designated by a three-digit basic code number; the first digit of the code number indicating the calorific value; the second the volatile matter, and the third the Gray-King (LT) coke type.

---

*Methods of test for coal and coke: Part II Determination of calorific value (*first revision*).

†Methods of test for coal and coke: Part I Proximate analysis (*first revision*).

‡Methods of test for coal carbonization — caking index, swelling properties and Gray-King assay (L.T.) coke types.

4.2 The supplementary parameter of moisture (M_u) shall be operative only in case of non-caking coals yielding poor coke type, that is, inferior to type 'C'.

NOTE — Normally coals having M_u value above 7 are poorly caking to completely non-caking.

4.3 Similarly, the supplementary parameter of MTPL shall be operative only in case of caking coals yielding G-K (LT) coke of type 'C' or better.

5. NUMBERING SYSTEM

5.0 General — The numbering system employed in the digited code numbers shall be as given in **5.1**.

5.1 Calorific Value — The calorific value, expressed on pure coal basis, shall be the first parameter and shall be divided into 9 groups, the range of which shall be as follows:

Group No.	*Range of Calorific Value, kcal/kg*		
1	6 150	to	6 950
2	6 955	,,	7 500
3	7 505	,,	7 800
4	7 805	,,	8 050
5	8 055	,,	8 250
6	8 255	,,	8 350
7	8 355	,,	8 500
8	8 505	,,	8 700
9	8 705	,,	8 900

5.2 Volatile Matter — Volatile matter, calculated on pure coal basis, shall be the second parameter and shall be divided into 10 groups, the range of which shall be as follows:

Group No.	*Range of Volatile Matter, Percent by Mass*		
0	above 50·0		
1	43·1	to	50·0
2	37·1	,,	43·0
3	33·1	,,	37·0
4	28·1	,,	33·0
5	22·1	,,	28·0
6	18·1	,,	22·0
7	15·1	,,	18·0
8	10·1	,,	15·0
9	10·0 and below		

5.3 Gray-King (LT) Coke Type — This shall be the third parameter, specifying the division of the coals into 6 groups characterized by their caking properties. The ranges of coke types with their group numbers shall be as follows:

Group No.	*Range of G-K (LT) Coke Type*
0	A — B
1	C — D
2	E — F
3	G
4	G_1 — G_2
5	G_3 and over

5.4 Maximum Thickness of Plastic Layer (MTPL) — The values of MTPL, supplementary parameter applicable only to caking/coking coals, that is, coals yielding coke type 'C' and above, shall be divided into 6 sub-groups, as follows:

Sub-group No.	*MTPL Range, mm*
1	8 to 12
2	13 to 16
3	17 to 19
4	20 to 22
5	23 to 25
6	26 and above

5.5 Moisture — The supplementary parameter of moisture (M_u) shall be divided into 6 sub-groups, applicable only in case of non-caking coals, that is, below 'C' Group of G-K (LT) coke type. The sub-groups with their moisture ranges shall be as follows:

Sub-group No.	*Moisture Range (M_u) percent by mass*
1	above 20·0
2	15·1 to 20·0
3	11·1 „ 15·0
4	9·1 „ 11·0
5	7·1 „ 9·0
6	5·1 „ 7·0

6. THE CODE CLASSIFICATION CHART

6.0 General — In constructing the code classification chart, as given in Table 1 all plausible and known combinations of the three basic parameters of properties of Indian coals and lignites, in terms of their group numbers have been taken into consideration. The supplementary parameters with their sub-group numbers have been provided in the right-hand side of the chart to extend the classification to the four-digit code number, wherever necessary.

6.0.1 In the code classification chart (*see* Table 1) coals having more or less similar properties and behaviour have been grouped and these are marked out as blocks with designations of *L*, *SB*, *B*, *SA* and *A*. Such sub-grouping shall be found useful in identifying coals for different end uses.

For example B_8 coals are likely to be prime caking coals, whereas coals of Groups B_3 to B_5 are high to medium volatile and blendable. Group L represents brown coals and lignites whereas Group B_1, high volatile, high sulphur, and both low and high moisture Assam coals.

6.1 Operation of the Code Classification Chart — The method of translating the three-digit basic code classification and extending the same to the four-digit integrated system by operating the supplementary parameters is illustrated as follows:

Example 1 — Suppose a caking coal with three-digit basic code number, say 855, has MTPL sub-group number of 6. The integrated code number of such a coal shall be 8556 which when decoded expresses the following properties:

a) Calorific value, kcal/kg	8 505 to 8 700
b) Volatile matter, percent by mass	22·1 to 28·0
c) G-K (LT) coke type	G_3 or above
d) MTPL, mm	26 and above

The above properties of the coal strongly indicate that it is likely to be a typical prime coking coal. On the other hand, if the basic code number of the coal remains the same, that is, 855, but the MTPL value is 3 instead of 6, its four-digit integrated code number shall become 8553, which would indicate a coal likely to be somewhat inferior to 8556 in respect of its cokeability.

Example 2 — Again, suppose a non-caking coal with a basic code number, say 330, has moisture (M_u) sub-group number 4, the integrated code number of this coal shall be 3304 and when decoded expresses the following properties:

a) Calorific value, kcal/kg	7 507 to 7 800
b) Volatile matter, percent by mass	33·1 to 37·0
c) G-K (LT) coke type	A
d) Moisture (M_u), percent by mass	9·1 to 11·0

The above properties would indicate that the coal is a fairly high moisture, high volatile, low rank, non-caking coal.

NOTE — All high volatile non-caking coals giving coke type below C, would obviously have 'C' as the third number and would thus be readily recognizable in terms of the three-digit basic code number. But all such non-caking coals are not equivalent in their intrinsic and/or technological properties, and herein lies the importance of the supplementary parameter, M_u, which subdivides such coals in terms of different moisture ranges.

7. CLASSIFICATION AND CODIFICATION OF COAL

7.1 Lignites, sub-bituminous, bituminous and anthracitic coals form the well-known 'coal series' in order of their general sequence of maturity and rank.

Most of the coal properties, physical and/or chemical, are systematically inter-related and thus, coals can be classified by their two or three intrinsic properties. In Table 2 classification of Indian coals, from lignites to anthracites, in terms of volatile matter and moisture, is given along with their general characteristics, properties, and recommended uses. The typical code number of the different groups of coal are also presented therein to provide a link between the general classification and the code classification, as given in 6 and Table 1.

APPENDIX A

(*Clause* 2.1)

DESCRIPTIONS AND EXPLANATIONS RELATING TO COAL

A-0. GENERAL

A-0.1 Some of the important descriptions and explanations relating to coal are given below for guidance.

A-1. COAL SERIES

A-1.1 Lignites, sub-bituminous, bituminous and anthracitic coals form the 'coal series' and are also broadly in order of their increasing rank. Peat is the earliest stage of coal formation but this is excluded in this classification. Lignite is earthy-brown in colour, bituminous coal is black, anthracites is shining black but pitch-like in appearance. Lignites are unconsolidated or consolidated. The coal series, right from lignite to anthracite are complex organic bodies, metamorphized in a systematic manner under geochemical conditions, but are invariably associated with varying proportions of inorganic matter of variable mineral composition. Lignites, in general, are low in mineral matter content but some Indian lignites record high values. Indian coals usually contain moderate to very high proportions of mineral constituents.

TABLE 1 CODE CLASSIFICATION OF INDIAN COALS AND LIGNITES

(*Clauses* 4.1, 6.0, 6.0.1 *and* 7.1)

CLASSIFICATION OF INDIAN COALS AND LIGNITES

CV kcal/kg (dmf) RANGE	CV GR No.	VM GR No. 0 (>50)	1 (50-43.1)	2 (43-37.1)	3 (37-33.1)	4 (33-28.1)	5 (28-22.1)	6 (22-16.1)	7 (16-15.1)	8 (15-10.1)	9 (<10.1)	GK COKE TYPE GR No.	GK COKE TYPE RANGE	MTPL mm GR No.	MTPL mm RANGE	MOISTURE Mu GR No.	MOISTURE Mu RANGE
8705-8900	9					B_6 945	955					5	G_3+	6 5 4 3	26+ 23-25 20-22 17-19		
						944	954					4	G_1-G_2	6 5 4 3	26+ 23-25 20-22 17-19		
						943	953	963				3	G				
								962				2	E-F				
								961 B_7				1	C-D				
												0	A-B				
8505-8700	8		B_3 - B_5		835	845	855					5	G_3+	6 5 4 3	26+ 23-25 20-22 17-19		< 5.1
					834	844	854					4	G_1-G_2	6 5 4 3	26+ 23-25 20-22 17-19		
					833	843	853					3	G	4 3	20-22 17-19		
					832	842	852	862				2	E-F	3 2	17-19 13-16		
						841	851	861	871		A	1	C-D	1	8-12		
									870	880	890	0	A-B		—		
8355-8500	7	B_1	715	725	735							5	G_3+	5 4 3	23-25 20-22 17-19		
		704	714	724	734				B_8	SA		4	G_1-G_2	4 3	20-22 17-19		
		703	713	723	733							3	G	3	17-19		
		702	712	722	732	742						2	E-F	2	13-16		
		701	711	721	731	741						1	C-D	1	8-12		
									770	780		0	A-B				
8255-8350	6		615	625								5	G_3+	3	17-19		
			614	624								4	G_1-G_2	2	13-16		
		603	613	623								3	G				
		602	612	622	632							2	E-F				
		601	611	621	631							1	C-D				
									670	680		0	A-B				
8055-8250	5		515									5	G_3+				
			514	B_3 - B_5								4	G_1-G_2				
		503	513									3	G				
		502	512									2	E-F				
		501	511	521	531							1	C-D			6	7-5.1
		500	510	520	530	540						0	A-B			5	9-7.1
7805-8050	4	400	410	420	430	440	450	B_2				0	A-B			5 4	9-7.1 11-9.1
7505-7800	3	300	310	320	330	340						0	A			5 4 3	9-7.1 11-9.1 15-11.1
6955-7500	2	200	210	220	230	SB						0	A			4 3 2	11-9.1 15-11.1 20-15.1
6150-6950	1	L 100										0	A			2 1	20-15.1 > 20
VM % (dmf)	GR No. / RANGE	0 >50	1 50-43.1	2 43-37.1	3 37-33.1	4 33-28.1	5 28-22.1	6 22-16.1	7 16-15.1	8 15-10.1	9 <10.1	GK COKE TYPE		MTPL			

NOTE 1 — Group numbers increase from bottom to top or from left to right. The numbers of supplementary parameters also increase from bottom to top in a given group.

NOTE 2 — Increasing group number means increasing desired property level depending on use, that is, lower moisture, higher CV, lower VM, coke type towards 'G', higher MTPL.

NOTE 3 — Blank spaces in the chart mean that coals of such properties are non-existent or have not been encountered.

NOTE 4 — The letters *L, SB, B*, etc, refer to the different classes of coals. (*see* Table 2).

3—304 Deptt. of BIS/2007

TABLE 2 CLASSIFICATION OF INDIAN COALS AND LIGNITES, THEIR PROPERTIES AND UTILIZATION

(*Clause* 7.1)

Class	Type	Symbol	Nature	Basic Parameters			Other Properties				Utilization
				CV kcal/kg (dmf)	VM Percent (dmf)	G-K Coke Type	Moisture (60% RH) Part/100 Parts Unit Coal	Carbon (dmf)	Hydrogen (dmf)	Code Number	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lignite	Consolidated	*L*	Non-caking	6 150-7 300	> 50	A	> 20	67-73	4·5-5·5	100, 200	Combustion, gasificatio briquetting, hydrogena-tion
Sub-bituminous	High volatile	*SB*	Non-caking	6 950-7 500	33-50	A	10-20	76-79·5	4·5-5·1	210, 220, 230	Gasification, combu:
Bituminous	High volatile (Assam coals)	B_1	Non-caking to strongly caking	7 500-8 500	> 45	A-C_1*	2-9	75-82·5	5·3-6·3	300, 400, 500, 501-3, 601-3 701-4, 310, 410, 510, 511-5, 611-5, 711-5	Hydrogenation, bi-combustion
	Medium volatile to High volatile	B_2	Non-caking	7 500-8 250	27-43	A-B	7-11	79·5-83·0	4·7-5·2	320, 420, 520, 330, 430, 530, 340, 440, 540, 450	Combustion, gasification, hydrogenation
	High volatile	B_3	Weakly caking	8 250-8 400	33-43	C-D	5-7	82·5-83·5	5·0-5·4	521-531, 621, 631, 721, 731	L T C, hydrogenation, blending
	High volatile	B_4	Medium to strongly caking	8 250-8 500	33-43	E-C_1*	2-5	83·5-87·5	5·0-5·8	622-5, 722-5, 632, 732-5, 832-5	Blending, hydrogenation
	Medium volatile	B_5	Weakly to medium caking	8 500-8 700	22-33	C-F	< 2	86·5-88·0	4·7-5·0	741-2, 841-2, 851-2	Blending
	Medium volatile	B_6	Strongly caking (prime coking coals)	8 500-8 900	22-33	G-G_1*	< 2	88-90·5	4·8-5·2	813-5, 943-5, 853-5, 953-5	Metallurgical coke makin
	Low volatile	B_7	Weakly to medium caking	8 500-8 900	18-22	C-G	< 2	90·5-91·5	4·5-4·9	861-2, 961-3	Blending, combustion
	Low volatile	B_8	Non-caking to weakly caking	8 250-8 700	15-18	A-D	< 2	91·5-92·0	4·2-4·5	670, 770, 870-1	Combustion, domestic use
Anthracite	Semi-anthracite	*SA*	Non-caking	8 250-8 700	10-15	A	< 2	92·0-93·0	3·7-4·2	680, 780, 880	Carbon artefacts, combustion, domestic use
	Anthracite	*A*	Non-caking	8 500-8 700	< 10	A	–	> 93	< 3·7	890	do

NOTE 1 — Based on available data, broad ranges of the properties are given.

NOTE 2 — Assam coals grouped together as B_1, constitute a special formation, exhibiting widely different coal characteristics.

*All coals are suitable for combustion and many for hydrogenation. However, keeping in view the prevailing technologies, national priorities, etc, the more common uses are indicated.

A-2. RANK OF COAL

A-2.1 This denotes the extent of maturity of coal in its metamorphic path. With the progressive metamorphism of lignite to anthracite, the carbon content, on pure coal basis, increases continuously from as low as 65 to as high as 96 to 97 percent with a corresponding decrease in oxygen from about 28-29 percent to almost nil at the highest rank anthracitic stage. The rank enhancement is also reflected in the volatile matter and moisture content of coal. Low rank coals are high volatile and/or high moisture in nature whereas high rank coals, in general, are medium to low volatile having moisture usually less than 2 percent.

A-3. PETROLOGY OF COAL

A-3.1 Coal is composite in nature, having a banded structure, especially in the bituminous rank level. Microscopically it is composed of organic entities called vitrinites, exinites and inertinites. Coal is thus a rock, made up of the organic macerals, which are invariably associated with varying proportions of mineral matter. The physical and chemical properties of the pure organic macerals of a coal are distinctly different from each other. The rank and maturity of these individual macerals progressively change with increasing coalification and with this, the differences in their physical and chemical properties, are progressively narrowed down, tending to merge at the anthracitic level, wherein the macerals become almost optically delimited. Thus, the properties of a coal at any stage of its rank-evolution is a sum-total of the individual properties of its macerals.

A-4. ANALYSIS AND TESTING OF COAL

A-4.1 This involves experimental work for obtaining necessary information on coals in so far as the present standard is concerned. The methods are described in different Indian Standards wherein the significance of the properties (tests/analysis results) has also been dealt with. However, for a ready reference, brief explanations of the terms used in this standard are included in the following clauses.

A-4.1.1 *Moisture on 60 percent Relative Humidity and 40°C Basis* — The moisture content of coal is variable depending on the conditions of the atmosphere. Air equilibrated moisture at 60 percent relative humidity and 40°C is a characteristic property of coal. This shall be determined by the procedure laid down in 6.7 of IS : 1350 (Part I)-1969*.

A-4.1.2 *Mineral Matter* — Coal is unavoidably associated, intrinsically and/or adventitiously, with some inorganic constituents, for which the composite name, mineral matter, is used. The chief minerals usually present in coal are: kaolinite, shale, quartz, siderite or ankerite (carbonate minerals), as well as pyrites of which usually shale and quartz are the predominant constituents.

*Methods of test for coal and coke: Part I Proximate analysis (*first revision*).

A-4.1.3 *Ash* — Ash is the inorganic residue left over after the complete incineration of a sample of coal under specified conditions. This is determined by the procedure laid down in 8 of IS : 1350 (Part I)-1969*.

A-4.1.3.1 Inorganic minerals chemically change during incineration and suffer loss in weight. Thus, the weight of ash is somewhat lower than the weight of the total mineral matter present in coal.

A-4.1.4 *Volatile Matter* — Tarry vapours, gases and water evolve from coal when it is heated under specified carbonization conditions and is expressed as the loss in weight (percentage), after correcting for the moisture content of coal.

A-4.1.5 *Fixed Carbon* — It is obtained by difference, that is, by deducting the sum-total of moisture, ash and volatile matter from the total weight of coal.

NOTE — The determination of moisture, ash, volatile matter and fixed carbon is collectively termed as proximate analysis of coal and this is laid down in IS : 1350 (Part I)-1969*.

A-4.1.6 *Calorific Value (Gross Calorific Value at Constant Volume)* — This is the amount of heat generated when coal is completely burnt under specified conditions and is expressed as kilocalories/kilogram of coal. The gross calorific value shall be determined in accordance with IS : 1350 (Part II)-1969†.

A-4.2 Ultimate Analysis of Coal — The coal substance, that is, coal bereft of mineral matter and moisture, is composed of a number of elements, for example, carbon, hydrogen, nitrogen, sulphur and oxygen. The determination of these elements is called the ultimate analysis of coal. The quantity of each element is expressed as the mass percentages of pure coal. The methods for these determinations are laid down in IS : 1350 (Part III)-1969‡, IS : 1350 (Part IV/Sec 1)-1974§ and IS : 1350 (Part IV/Sec 2)-1975‖.

A-5. GRAY-KING (LT) COKE TYPE

A-5.1 The determination of Gray-King (LT) coke type is a part of low temperature assay which indicates the carbonization potentialities of a coal. This is laid down in IS : 1353-1959¶. The coke type shall be determined accordingly.

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*Methods of test for coal and coke: Part I Proximate analysis (*first revision*).

†Methods of test for coal and coke: Part II Determination of calorific value (*first revision*).

‡Methods of test for coal and coke: Part III Determination of sulphur (*first revision*).

§Methods of test for coal and coke: Part IV Ultimate analysis, Section 1 Determination of carbon and hydrogen (*first revision*).

‖Methods of test for coal and coke: Part IV Ultimate analysis, Section 2 Determination of nitrogen (*first revision*).

¶Methods of test for coal carbonization — caking index, swelling properties and Gray-King assay (L.T.) coke types.

A-6. PURE COAL

A-6.1 Pure coal (also referred to as ' unit coal ' or dry mineral matter-free coal) is the organic part of coal and is also called the coal substance. It is the coal free from its natural moisture and mineral matter. It is this part which governs the fundamental properties of a coal. The physical and chemical properties of coal are usually calculated on the basis of the pure coal for the evaluation of the maturity, rank and the intrinsic properties of the coal.

A-7. EVALUATION OF MINERAL MATTER (MM)

A-7.1 For the computation of the proportion of pure coal as well as for the conversion of the analytical data of coal to the pure coal basis, mineral matter of coal has to be determined and/or computed from the ash content of coal. Usually, the mineral matter content of coal is computed from its ash and other data.

A-7.1.1 For most of the Indian coals, containing low proportions of sulphur and ' carbonate ' minerals, the general formula for the computation of mineral matter shall be as follows:

$$\text{Mineral matter} = 1{\cdot}1 \times A$$

where

A represents percent ash content of a coal but when the ' carbonate ' carbon dioxide content (which is indicative of the proportion of the ' carbonate ' minerals) is known and does not exceed 1 percent, the formula for mineral matter shall be as follows:

$$\text{Mineral matter} = 1{\cdot}1\ A + 0{\cdot}7\ CO_2$$

where

CO_2 = the percent ' carbonate ' carbon dioxide content in coal.

A-7.1.2 Usually, the major carbonate mineral in coal is siderite, that is, ferrous carbonate and in such cases the factor of 0·7 holds good. But where ' carbonate ' CO_2 exceeds 1 percent, carbonates other than siderite, such as calcium carbonate, magnesium carbonate and ankerite are likely to be present in substantial proportions and in such cases, the factor shall have to be worked out by analysis of the carbonates.

A-7.1.3 Again, where sulphur content is more than 1 percent, the formula shall be as follows:

$$\text{Mineral matter} = 1{\cdot}08\ A + 0{\cdot}55\ Spyr$$

where

$Spyr$ = percent sulphur occurring as pyrites.

A-7.1.4 In case where both sulphur and 'carbonate' corbon dioxide contents are high, the following formula may be used:

$$\text{Mineral matter} = 1{\cdot}08\ A + 0{\cdot}55\ Spyr + 0{\cdot}7\ CO_2$$

A-7.1.5 In case of coals and lignites where ash content is below 5 percent or so, the mineral matter may be roundly taken to be numerically equal to the ash content. Although such a guideline may be largely correct, it is, however, safer to determine the mineral matter content by experimental method for a more precise evaluation.

A-8. CONVERSION OF COAL PROPERTIES TO PURE COAL BASIS

A-8.1 Calorific Value — For conversion of calorific value (CV) to pure coal basis, the formula shall be as follows:

$$\text{Calorific value (dmf)} = \frac{(\text{Calorific value as determined}) \times 100}{100 - (\text{mineral matter} + \text{moisture})}$$

In case of coals having high sulphur (more than 1 percent), the determined calorific value is to be corrected for heat generated due to the combustion of pyrites by deducting 27·8 times *Spyr*.

A-8.2 Volatile Matter — For conversion of volatile matter to pure coal basis, fixed carbon (FC) obtained by difference in the proximate analysis, is converted to pure coal basis by the following formula and the volatile matter on pure coal basis (VM dmf) is derived therefrom:

$$\text{Fixed carbon (dmf)} = \frac{(\text{Fixed carbon as determined}) \times 100}{100 - (\text{mineral matter} + \text{moisture})}$$

$$\text{Volatile matter (dmf)} = 100 - \text{fixed carbon (dmf)}$$

A-8.3 Moisture — For the conversion of percent air-equilibrated moisture (M), determined at 60 percent relative humidity and 40°C, to parts per 100 parts of coal substance, the formula shall be as follows:

$$M_u = \frac{M \times 100}{100 - (\text{mineral matter} + M)}$$

where

M_u = parts of moisture per 100 parts of coal substance.

APPENDIX B

(*Clause* 3.5)

SAPOZHNIKOV PLASTOMETRIC TEST*

B-0. PRINCIPLE

B-0.1 When a caking coal is subjected to uni-directional heating (from bottom), the plastic layer and (resolidified) semi-coke layer progressively moves upward and under the test conditions, the relative movement of the semicoke-plastic fluid/plastic fluid-green coal interfaces passes through a maximum value which is measured in this test.

B-0.2 The measurement of the layer thickness is made feasible by an ingenuous technique of maintaining a capillary column in the bed (coal charge).

B-1. APPARATUS

B-1.1 The test apparatus comprises a cup-shell and other accessories. The cup-shell is a cylindrical steel vessel, 120 mm high, 60 mm in internal diameter, and 70 mm in external diameter. It consists of detachable perforated bottom, with positioned groove for thermo-couple sheath and a top cover, suitably-holed for insertion of thermo-couple sheath and penetrometer needle.

Top cover is coupled with lever arrangement to keep the system under desired pressure by using weights. Other accessories are as given below.

B-1.1.1 *Suitable Electrical Equipment for Heating the Cup-Shell*

B-1.1.2 *Thermo-Couple with Calibrated Pyrometer*

B-1.1.3 *Calibrated Penetrometer Needle*

B-1.1.4 *Thin Metallic Rod 2·5 mm diameter*

B-1.1.5 *Asbestos Discs/Paper*

B-1.1.6 *Thin Tracing Paper*

B-2. PROCEDURE

B-2.1 Thoroughly clean the cup-shell (using the special device provided for the purpose), slide the bottom disc and cover the internal surfaces with the asbestos disc/paper. Set in position thermocouple with sheath and the thin metallic rod wound with the tracing paper (at the coal-end).

*SAPOZHNIKOV (L M) and BAZILEVICH (L P). Investigations of the coking process 1938. State Publishing House, Ukrine, Kharkov, P 5-33.

Charge 100 g of coal passing through 1·18-mm IS sieve, spread uniformly and cover with asbestos disc (suitably-holed) and bring the top cover in position. The heating shall be such as to register the temperature of 150°C in 30 minutes; thereafter the heating rate shall be 3°C per minute. When the temperature reads 300°C, pull out the thin rod whereby the capillary is formed. Using the penetrometer needle, record the plastic layer thickness as obtained in the capillary at 10-minute intervals in the temperature range of 300-400°C and at 5-minute intervals during the peak period.

B-3. TEST REPORT

B-3.1 Report the maximum value of the layer thickness (assessed by plotting the data), rounded to the nearest millimetre. Stop the experiment when the temperature reaches 730°C.

NOTE — For Indian coking coals the MTPL values range from 8 to 30 mm. Usually, metallurgical coking coals have values between 17 and 30 mm.

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