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(तीसरा पुनरीक्षण)

Indian Standard

CLASSIFICATION AND CODIFICATION OF INDIAN COALS, LIGNITES AND SEMI-ANTHRACITES

(Third Revision)

ICS 73.040

B U R E A U O F I N D I A N S T A N D A R D S
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Solid Mineral Fuels Sectional Committee, PCD 7

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Solid Mineral Fuels Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

This standard was first published in 1955 and revised in 1964 mainly to introduce metric system of units. The second revision of this standard was issued in 1977 to offset IS 5018 : 1968 'Classification of hard coals by type' as the two were overlapping and repetitive in nature and there was scope for merging the two into a more meaningful and comprehensive standard. The Committee responsible for the formulation of this standard decided to revise it again on the basis of past experiences and also in the light of the present day context. Radical changes have since taken place in the consideration of basic parameters for classification of coal resulting in a new system encompassing a wide range of source availability and end use.

In the second revision classification of coal was based on three basic parameters, namely, gross calorific value, volatile matter and Gray-King (LT) coke type and two supplementary parameters comprising maximum thickness of plastic layer (MTPL) for caking coal and air-equilibrated moisture at 60 percent relative humidity and 40°C for non-caking coal. In codification system, each type of coal was designated by a three-digit basic code number, indicating calorific value, volatile matter and Gray-King (LT) coke type in that sequence. The fourth digit became operative with suitable code number for moisture content (M_u) in the case of non-caking coals or a code number for supplementary parameter of MTPL for caking coal.

Petrographic approach towards coal classification is fast emerging as an important adjunct (also internationally) and it has been established that the petrographic properties of coals have significant influence in the application of caking coal sector and are finding increasing applications in guiding coal utilization, particularly in the area of power sector.

The physical and chemical properties of a coal are dependent on the geological maturity (rank) and on the petrographic composition. In the present revision, volatile matter (dry mineral matter free basis, dmf), mean reflectance (random) of coal and gross calorific value have been considered as the basic parameters. The supplementary parameters that is capacity moisture equilibrated at 96 percent relative humidity and 40°C for non-caking coals; Gray-King (LT) coke type and crucible swelling number (CSN) for caking coals are considered to cover a wide range of sources available in India.

Coals needed for specific industrial applications such as steel, power and cement sectors are being given special stress through separate standards. The code given here forms the broad structure but details for various end uses are given in the respective product specifications.

The definitions given in this standard do not specify the boundaries that apply to the descriptive terms used, which all relate to the geological maturity (rank) of the coals. There is no simple system for the classification of coals that can provide, on a comparative basis, an indication of coal characteristics on a worldwide basis, therefore, this standard only provides a basis for addressing these issues.

In the formulation of this standard, valuable inputs have been obtained from the extensive studies carried out by Central Institute of Mining & Fuel Research (erstwhile Central Fuel Research Institute), Dhanbad, Central Mine Planning & Design Institute Ltd (CMPDI), Ranchi and other related organizations in the field.

Indian Standard

CLASSIFICATION AND CODIFICATION OF INDIAN COALS, LIGNITES AND SEMI-ANTHRACITES

(Third Revision)

1 SCOPE

1.1 The standard specifies the classification and codification by type and quality of Indian coals including lignites and semi-anthracites. It also deals with the established correlations between the chosen parameters and other coal properties (*see* Annex A)

1.2 This classification is not intended to be used for commercial purposes because the assessment and selection of coals for a specific purpose require detailed information that enables the likely performance of a coal in a particular application to be anticipated.

1.3 This standard does not cover the aspects of 'Size analysis of coal and coke for marketing' which is covered in IS 437 : 1979 'Size analysis of coal and coke for marketing (*third revision*)'.

1.4 Sulphur, phosphorus, chlorine, mercury and arsenic content in coal are important for taking necessary precautions in regard to the up keeping of the industrial appliances, maintaining the quality of manufactured materials (using the coal/coke) and/or for controlling the atmospheric pollution. These aspects are not covered in this standard.

1.5 Grindability of coal (*see* IS 4433 : 1979 'Methods for determination of hardgrove grindability index of coal') and information on the composition and fusion characteristics of the coal ash are important in the formulation of scheme for rational utilization of coals; but these aspects are not covered in this standard.

2 REFERENCES

The standards listed below contain provisions which, through reference in text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

IS No.	*Title*
1350 (Part 1) : 1984	Methods of test for coal and coke: Proximate analysis (*second revision*)
(Part 2) : 1970	Determination of calorific value (*first revision*)
1353 : 1993	Methods of test for coal carbonization — Caking index, swelling number and (LT) Gray-King assay (*first revision*)
3810 (Part 1) : 2002	Solid mineral fuels — Vocabulary: Terms relating to coal preparation (*second revision*)
(Part 2) : 2003	Terms relating to sampling, testing and analysis (*first revision*)
9127 (Part1) : 1992	Methods of petrographic analysis of coal: Part 1 Definition of terms relating to petrographic analysis of coal (*first revision*)
9127 (Part 5) : 2004/ISO 7404-5 : 1994	Methods for the petrographic analysis of bituminous coal and anthracite: Part 5 Method of determining microscopically the reflectance of vitrinite (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions relating to coal as given in IS 3810 (Part 1) and IS 3810 (Part 2) shall apply. Definitions relating to petrographic analysis of coal as given in IS 9127 (Part 1) shall apply.

4 CLASSIFICATION PARAMETERS

The classification is essentially based on the following two sets of parameters.

4.1 Basic Parameters

The three basic parameters required for classifying the given coal are as follows:

a) Mean random reflectance;
b) Volatile matter (dry mineral matter free basis, dmf); and
c) Gross calorific value (dry mineral matter free basis, dmf).

4.1.1 *Mean Random Reflectance*

The reflectance of a coal indicates the geological

maturity, determined on vitrinite grains that gradually increases from lignite, sub-bituminous, bituminous, semi-anthracite and anthracite. The vitrinite reflectance is the proportion (percentage) of direct incident light that is reflected from polished vitrinite surface usually under oil immersion. It shall be determined in accordance with IS 9127 (Part 5).

NOTE — The maceral composition may also be considered for better assessment of coal quality. There are four broad groups of macerals, namely vitrinite, semi-vitrinite, liptinite and inertinite. Vitrinite, semi-vitrinite and liptinite are known as reactive micro-components from carbonization point of view. Moreover, the inertinite in non-caking coals also plays a vital role in case of combustion.

4.1.2 *Volatile Matter Content*

The matter released as volatile products during pyrolysis of coal, in absence of air under specified conditions is known as volatile matter of coal. The volatile matter of coal is of particular importance in assessing the use for which the coal is suitable by itself or in conjunction with other characteristics. It is determined following the procedure as per IS 1350 (Part 1) and is expressed on dry mineral matter free basis (dmf). However, for lignite, *Jhama*/heat affected coal, it is suggested for attaining the conversion on dry ash free basis (daf) instead of dry mineral matter free basis (dmf).

4.1.3 *Gross Calorific Value*

The gross calorific value (at constant volume) is the number of heat units evolved by the complete combustion of unit mass of a combustible material. This shall be on pure coal basis that is dmf, and shall be determined in accordance with IS 1350 (Part 2). However, for lignite, *Jhama*/heat affected coal; it is suggested for attaining the conversion on dry ash free basis (daf).

4.2 Supplementary Parameters

The three supplementary parameters required for classifying the given coal are as follows:

a) Capacity moisture equilibrated at 96 percent relative humidity and 40°C;
b) Gray King low temperature (GKLT) coke type; and
c) Crucible swelling number (CSN).

4.2.1 *Moisture Content (Non-caking Coals)*

The moisture content of coal under equilibrated condition is an intrinsic property and it indicates the maturity of a coal. But in case of low volatile non-caking coal (*see* **5.2.1**), where moisture is less than 2.0 percent, only air-dried moisture can be considered. The existing Indian Standard on equilibrated moisture is based on 60 percent relative humidity and 40°C. Keeping in view the international standards, the capacity moisture determined at 96 percent relative humidity and 40°C in accordance with IS 1350 (Part 1), is to be considered as inherent moisture.

NOTE — Ash content is not considered as a classification parameter as it is not a carbonaceous material. However, this direct experimental data (which has to be expressed on the moisture basis as used in **4.2.1**) may be considered for better assessment of coal quality.

4.2.2 *Gray King Low Temperature (GKLT) Coke Type*

Gray King low temperature (GKLT) coke type as obtained for the coal is used for classifying caking coals (mean random reflectance R_r percent ≥ 0.65). The GKLT coke type as well as other carbonization parameters depend on maceral (micro component of coal) composition and rank of the coal. The test shall be carried out in accordance with IS 1353 (*see* Note under **4.2.1**).

4.2.3 *Crucible Swelling Number (CSN)*

The swelling number of coal, as determined by the crucible swelling number (CSN) test is intended solely to give some comparative measure of the swelling/caking properties of coal. It shall be determined in accordance with IS 1353 (*see* Note under **4.2.1**).

5 NUMBERING SYSTEM

5.0 General

The classification of coals is fairly simple and definitive in terms of the four or five digit code number. In practice, it is necessary, at times, to supplement or present the information in a descriptive manner along with the code. Each of the basic and supplementary parameters is set into definite range designated by numerical indices. The code number assigned to a particular coal is obtained by putting together the numerical indices within ranges for the classification by individual numbers. Attempts have been made to describe the type of coals in terms of maturity in the col 3 of Tables 1 to 6. For the coals of same parametric values, coal of higher maturity is described as "A" and so on.

5.1 Basic Parameters

The ranges set and the numbers assigned for the different classification parameters are as follows.

5.1.1 *Mean Random Reflectance*

This is taken as the first parameter for codification of coals. The mean random reflectance as given in Table 1, represents the maturity of a coal (rank). It is measured on the random orientation of vitrinite grains and termed as mean random reflectance percent (R_r, percent), which

progressively increases with increasing rank. This parameter truly reflects the degree of coalification, because it is independent of further genetic peculiarities in the coal substance.

5.1.2 *Volatile Matter*

Volatile matter, calculated on dry mineral matter free basis (dmf), shall be the second parameter. The numerical codes for different ranges of volatile matter are shown in Table 2. Higher the number, higher is the rank of the coal.

5.1.3 *Gross Calorific Value (GCV)*

The gross calorific value (GCV) expressed on dry mineral matter free basis (dmf), is third parameter and is expressed into nine groups as given in Table 3.

5.2 Supplementary Parameters

The ranges and number set for the supplementary parameter are as follows.

5.2.1 *Moisture (Applicable to Non-caking Coal)*

The moisture content of non-caking coal for various types of coal is given in Table 4.

Table 1 Mean Random Reflectance
(*Clauses* 5.0 *and* 5.1.1)

Sl No.	Mean Random Reflectance (R_r, Percent)	Numerical Code	Type of Coal
(1)	(2)	(3)	(4)
i)	≥0.28 – 0.38	0	Lignite
ii)	>0.38 – 0.55	1	Sub-bituminous
iii)	>0.55 – 0.64	2	High volatile non-caking bituminous
iv)	≥0.65 – 0.84	3	High volatile caking bituminous B coal
v)	≥0.85 – 0.94	4	High volatile caking bituminous A coal
vi)	≥0.95 – 1.19	5	Medium volatile caking bituminous coal
vii)	≥1.20 – 1.39	6	Medium to low volatile caking bituminous coal
viii)	≥1.40 – 1.79	7	Low volatile caking bituminous coal
ix)	≥1.80 – 1.99	8	Low volatile non-caking bituminous coal
x)	≥2.00 – 2.50	9	Semi-anthracite

NOTE — In case of Indian coals, reflectance on vitrinite grains is generally measured as mean random reflectance, unlike the global practice where such measurements are usually recorded as maximum reflectance of vitrinite [$R_o(Max)$ percent]. However, vitrinite reflectance at random orientation (Mean R_r percent) of the grains has been considered up to high rank coals (semi-anthracite). From anthracite stage onwards, measurement of mean maximum reflectance percent [R_o (Max) percent], instead of mean random reflectance percent (Mean R_r percent) may be the preferred option for accurate rank determination.

Table 2 Volatile Matter on Dry Mineral Matter Free Basis (dmf)
(*Clause* 5.1.2)

Sl No.	Volatile Matter Percent	Numerical Code	Type of Coal
(1)	(2)	(3)	(4)
i)	> 45.0	0	Lignite/Tertiary high sulphur coals
ii)	>37.0 – 45.0	1	Sub-bituminous/Tertiary high sulphur coals
iii)	>37.0 – 43.0	2	Bituminous, high volatile 'B'/Tertiary coals
iv)	>32.0 – 37.0	3	Bituminous high volatile 'A'
v)	>28.0 – 32.0	4	Bituminous medium volatile
vi)	>22.0 – 28.0	5	Bituminous medium volatile
vii)	>15.0 – 22.0	6	Bituminous low volatile
viii)	>10.0 – 15.0	7	Bituminous very low volatile
ix)	<10.0	8	Semi-anthracite

NOTE — The volatile matter range of 37.0-45.0 percent is normally a characteristic of high moisture coal of sub-bituminous nature. But in tertiary coals of Assam coalfields, due to certain special geochemical circumstances, in the same volatile matter range or higher both non-caking coals and caking coals of high sulphur content occur. Even the non-caking coals of Assam are radically different in their nature in reference to the normal sub-bituminous Gondwana coals.

Table 3 Gross Calorific Value (GCV) on Dry Mineral Matter Free Basis (dmf)
(*Clause* 5.1.3)

Sl No.	Gross Calorific Value kcal/kg	Numerical Code	Type of Coal
(1)	(2)	(3)	(4)
i)	6 150 – 6 950	1	Lignite
ii)	>6 950 – 7 500	2	Sub-bituminous (High VM)
iii)	>7 500 – 7 800	3	Bituminous high volatile non-caking
iv)	>7 800 – 8 100	4	Bituminous medium to high volatile non-caking
v)	>8 100 – 8 200	5	Bituminous high to medium volatile non-caking to weakly caking coal
vi)	>8 200 – 8 350	6	High volatile weak to medium caking
vii)	>8 350 – 8 500	7	High volatile medium to strongly caking
viii)	>8 500 – 8 700	8	Medium to low volatile, 'B'
ix)	>8 700 – 8 900	9	Medium to low volatile, 'A'

NOTE — If calorific value is ≤ 7 300 kcal/kg but moisture content (at 96 percent relative humidity and 40°C) is ≥ 29.5 percent then it would fall in the lignite group. Semi-anthracite may have the GCV value in the range of 8 250 - 8 700 kcal/kg.

Table 4 Moisture Content of Non-caking Coal on Mineral Matter Free Basis
(*Clause* 5.2.1)

Sl No.	Percent Moisture (96 Percent Relative Humidity and at 40 °C)	Numerical Code	Type of Coal
(1)	(2)	(3)	(4)
i)	<3.0 (<2.0 air dried)	7	Low moisture
ii)	>3.0 – 6.0 (≤ 2.0 – 4.0)	6	Moderate moisture, 'A'
iii)	>6.0 – 9.0 (>4.0 – 6.5)	5	Moderate moisture, 'B'
iv)	>9.0 – 12.0 (>5.5 – 9.0)	4	High moisture, 'A'
v)	>12.0 – 15.0 (>8.5 – 12.0)	3	High moisture, 'B'
vi)	>15.0 – 30.0 (>12.0 – 24.0)	2	Very high moisture/ lignite, 'A'
vii)	>30.0 (>24.0)	1	Lignite 'B'

NOTES

1 The numbers are set in the reverse order of moisture content in compliance with increase in rank with decrease in moisture content (barring the natural reversal to slightly higher moisture content in the anthracitic stages). This implies that a high moisture coal with low coded value will denote lower rank.

2 Percent moisture is to be determined by equilibrating the coal at 96 percent relative humidity and at 40°C. However, if moisture determination is done at other ambient conditions, the deviation has to be specified so that a provisional assessment of the degree of departure in the moisture value is conceivable. The figures in parentheses are indicative of the equilibrated moisture determined at 60 percent relative humidity and at 40°C.

5.2.2 *Gray King Low Temperature (GKLT) Coke Type (Applicable to Caking Coal)*

This is the supplementary parameter for caking-coals. For the purpose of classification, the individual coke types, determined in accordance with IS 1353, are given in Table 5.

Table 5 Gray King Low Temperature (GKLT) Coke Type of Caking Coal

Sl No.	Range	Numerical Code	Descriptive Term
(1)	(2)	(3)	(4)
i)	C – D	1	Weakly caking
ii)	E – F	2	Moderately caking
iii)	G – G1	3	Strongly caking
iv)	G2 and above	4	Very strongly caking

NOTE — The numbering is so set that an increase in the number indicates a higher caking propensity in the coal (barring the special reservations in regard to the very high coke type values and the coke strength).

5.2.3 *Crucible Swelling Number (Applicable to Caking Coal)*

This is the supplementary parameter for caking-coals. For the classification purpose, the individual crucible swelling numbers, determined in accordance with IS 1353, are given in Table 6. The swelling property of a coal is dependent on rank, as well as on percentage of the reactive macerals.

Table 6 Crucible Swelling Number (CSN) of Caking Coal
(*Clause* 5.2.3)

Sl No.	Crucible Swelling Number (CSN)	Numerical Code	Type of Coal
(1)	(2)	(3)	(4)
i)	1 – 3	1	Low swelling
ii)	≥3 – 5	2	Moderately swelling
iii)	≥5 – 8	3	Highly swelling
iv)	>8	4	Very highly swelling

5.3 Ash Content

Ash is not considered as a classification parameter as it is not a carbonaceous material. However, considering the dilution effect of ash on caking properties, as well as heat value and other combustion properties, this parameter is taken into consideration for showing the quality of coal from utilization point of view. The categorization of caking and non-caking coals is given in Table 7 and Table 8 respectively.

Table 7 Ash Content of Caking Coal

Sl No.	Ash, Percent	Type
(1)	(2)	(3)
i)	<10.0	Very low ash
ii)	10.0 – 17.0	Low ash
iii)	>17.0 – 22.0	Medium ash
iv)	>22.0 – 28.0	Moderately high ash
v)	>28.0	High ash

NOTE — Ash content (direct experimental data) may be considered for better assessment of coal quality. A coal with high ash content, even if classified as caking from the tests of basic parameters may not show caking properties by supplementary tests. If the mean random reflectance percent (R_r, percent) of the coal is ≥ 0.65 and < 1.80 and the ash content is greater than 19 percent, the coal has to be prepared by Float and Sink method to reduce the ash content at 18 ± 1 percent or below prior to further testing for supplementary parameters.

Table 8 Ash Content of Non-caking Coal
(*Clause* 5.3)

Sl No.	Ash, Percent (Equilibrated Moisture Basis)	Type
(1)	(2)	(3)
i)	<15.0	Very low ash
ii)	15.0 – 22.0	Low ash
iii)	22.1 – 34.0	Medium ash
iv)	34.1 – 45.0	Moderately high ash
v)	>45.0	High ash

NOTE — The ash content values are to be reported on 96 percent relative humidity and 40°C equilibrated basis or air dried basis.

6 THE CODE CLASSIFICATION CHART

6.1 The distinction between the proportions of elemental carbon in the various coals are not so well defined and extreme caution is advised in attempting to equate coal rank with proportions of elemental carbon. However, it is sometimes desired to know the total carbon, hydrogen in a coal. The usual values corresponding to the types and groups of the classification are indicated in Table 9.

Table 9 Composition of Indian Coals/Lignite on dmf Basis

Sl No.	Type	Carbon Percent	Hydrogen Percent
(1)	(2)	(3)	(4)
i)	Lignite	67.0 – 72.0	4.8 – 5.5
ii)	Sub-bituminous (high-volatile)	≥75.0 – 78.0	4.5 – 5.0
iii)	Bituminous (non-caking)	>78.0 – 83.0	4.5 – 5.5
iv)	Bituminous high volatile (caking)	>83.5 – 86.0	5.0 – 5.8
v)	Bituminous high to medium volatile (caking)	>86.0 – 91.0	4.5 – 5.1
vi)	Bituminous (low-volatile non-caking)	>91.0 – 92.0	4.2 – 4.8
vii)	Semi-anthracite	>92.0 – 93.5	3.7 – 4.5

6.2 A broad grouping of Indian coals and lignites into different classes along with the rational utilization of non-caking and caking varieties of coals is given in Table 10. This classification system as such is versatile so that any coal or lignite would find a suitable composite code number. Therefore, new entrant can be placed into a suitable class depending on the characteristics of the particular resource. It is to be mentioned that half of the total reserve of the coking coal of the country is categorized as low volatile coking (LVC) coal. It has been established through extensive studies that these coals by proper beneficiation, yield a product, which is highly caking in nature and is suitable for metallurgical purpose. The other products of beneficiation are suitable for other end uses such as foundry, power sector, etc. These run of mines (ROM) coals are, at present, being utilized by the power sector. Keeping in view the high demand-supply gap of metallurgical grade coal, it appears that the present practice of the utilization of these coals for power generation is not judicious.

NOTE — While the system of classification has been considerably simplified in terms of number of parameters, at the same time, the resolving capacity has substantially increased leading to a large number of composite code numbers for coals and lignites. Further sub-division of coals (and lignites) in terms of ash level in addition to variation of volatile matter (18 to >45 percent, dry mineral matter free basis (dmf)/ dry ash free basis (daf) *vis-à-vis* moisture for non-caking coal or coking character for caking coal) has been responsible for this feature.

7 OPERATION OF THE CODE CLASSIFICATION CHART

7.0 General

Using the numerical codes for the classification parameters, the non-caking coals and caking coals are classified by a set of four digits and five digits respectively — each digit representing a particular parameter. A few examples may be cited as below to explain the codification of coals of different classes. The coding is done in the order of mean random reflectance, volatile matter content and gross calorific value as basic parameters. In case of non-caking coal, equilibrated moisture has been considered as fourth (supplementary) parameter and for caking coal, Gray King low temperature (GKLT) coke type and crucible swelling number (CSN) have been considered as fourth and fifth (supplementary) parameters respectively.

7.1 Example 1

A coal analyzing 0.45 Mean R_r percent, 37.3 percent (dmf) volatile matter, 7 350 kcal/kg (dmf) gross calorific value and 12.3 percent equilibrated moisture (96 percent relative humidity and 40°C) shall have the code number 1-1(or 2)-2-3. The four digit code indicates high moisture, high volatile matter, sub-bituminous coal (*see* Table 10).

7.2 Example 2

A coal analyzing 0.62 Mean R_r percent, 31.8 percent (dmf) volatile matter, 7 600 kcal/kg (dmf) gross calorific value and 10.0 percent equilibrated moisture shall have the code 2-4-3-4 (*see* Table 10).

7.3 Example 3

A coal analyzing 1.18 Mean R_r percent, 25.0 percent (dmf) volatile matter, 8 600 kcal/kg (dmf) gross calorific value, GKLT coke type G2 and CSN of 4 shall have the code 5-5-8-4-2. This coal is a medium volatile, very strongly caking coal with a fair amount of reactive maceral.

NOTE — 5 digit code clearly shows the caking nature of the particular coal.

7.4 Example 4

A coal analyzing 1.91 Mean R_r percent, 12.0 percent (dmf) volatile matter, 8 750 kcal/kg (dmf) gross calorific value and 0.8 percent air-dried moisture shall have the code 8-7-9-7. This code number indicates a low volatile, high rank non-caking coal.

Table 10 Classification and Codification of Indian Coals and Lignites and Their Properties

(*Clauses* 6.2, 7.1 *and* 7.2)

Sl No.	Class and Type	Nature	Basic Parameters			Supplementary Parameters			Code Number
			Mean Random Reflectance (R_r, Percent)	Volatile Matter Percent dmf	Gross Calorific Value (kcal/kg) dmf	Moisture Percent at 96 Percent Relative Humidity and 40°C° (Mineral Matter Free Basis)	GKLT Coke Type	CSN	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Lignite	Non-caking	>0.28-0.38	>45.0	>6 150-6 950	>30 (>24)			0-0-1-1
ii)	Sub-bituminous	Non-caking	>0.38-0.55	>37.0-45.0	>6 950-7 500	15-25 (>12)			1-1/2-2-2
iii)	High volatile bituminous	Non-caking	>0.55-0.64	>33.0-43.0	>7 500-7 800	11-18 (8-14)			2-2/3-3-2/3
iv)	High volatile bituminous	Weakly caking	≥0.65-0.84	32.0-43.0	>7 800-8 100	5-9 (4 - 7)	C-D	1-3	3-2/3-4-1-1
v)	Medium volatile bituminous	Medium to strongly caking	≥0.85-0.94	27.0-33.0	>8 250-8 500	<4 (<2.5-3.0)	E-G2	3-6	4-3/4/5-6/7-2/3/4-2/3
vi)	Medium volatile bituminous	Strongly caking	≥0.95-1.19	22.0-28.0	>8 500-8 900	<2 (<2)	G-G3	4-6	5-5-8/9-3/4-2/3
vii)	Bituminous	Strongly caking (Medium — Low volatile)	≥1.20-1.40	18.0 - 24.0	>8 500-8 900	—	F-G3	3-5	6-5/6-8/9-2/3/4-2
viii)	Low volatile bituminous	Low volatile weakly caking	≥1.41-1.79	14.0 - 17.0	8 250-8 700	—	C-D	1-3	7-6/7-6/7/8-1-1
ix)	Low volatile bituminous	Low volatile Non-caking	≥1.80-1.99	12.0 -15.0	8 250-8 700	<3	—	—	8-7-6/7/8-7
x)	Semi-anthracite	Non-caking	≥2.00-2.50	≤10.0-14.0	8 250-8 700	2-4	—	—	9-7-6/7/8-7/6
xi)	Tertiary (Assam coal)	Non-caking	0.36-0.60	>45.00	6 950-7 500	15-20 (10-15)	—	—	0/1/2-0-2-2
		Caking	>0.60-0.80	>40.00	7 500-8 500	—	C-G1	5-7	2/3-0/1-3/4/5/6/7-1/2/3-3

NOTE — The figures in parentheses are indicative of the equilibrated moisture determined at 60 percent relative humidity and 40°C.

ANNEX A

(*Clause* 1.1)

DESCRIPTIONS AND EXPLANATIONS RELATING TO COAL

A-0 GENERAL

The present classification system is principally based on the typology of coal. A brief appraisal of the typological character of coal and the parallel effects that influence the typological character is given below for guidance.

A-1 COAL SERIES

A-1.1 The broad 'milestones' in the typological changes of coal arising out of progressive rank enhancement, may be stated as lignite, bituminous and semi-anthracitic coals from the coal series, as far as the Indian scenario is concerned. Though coal is formed from vegetable origin through an encatchment in the form of a peat deposits, peat is considered only as a precursor and is not reckoned as a member of what is popularly known as the coal series.

Lignite forms the starting point of the series, first being 'unconsolidated' lignite followed by the 'consolidated' type. At the terminating end of the 'coal series', normally anthracites of different types occur but under Indian condition (as known so far) no true anthracites have been found. In a selected-patch in the Daltonganj coalfield of Jharkhand, semi-anthracitic formations occurred and in the Jammu region, pseudo-anthracitic formations, though much younger by age (Tertiary) are found to occur due to Himalayan movements. As a general guideline it may be mentioned that the coal series (from lignite to anthracite) represents progressive carbonification of the starting mass.

A-2 RANK OF COAL

A-2.1 This denotes the extent of maturity of coal in its metamorphic path. With the progressive metamorphism from lignite to anthracite, the carbon content on pure coal basis, increases gradually from as low as 65 to as high as 96 to 97 percent at the highest rank anthracitic stage. The rank enhancement is also reflected in the volatile matter and moisture content of coal or by increase of reflectance of vitrinite. Low rank coals are high volatile, high moisture and show low reflectance whereas high rank coals, in general, are medium to low volatile having moisture usually less than 2 percent and with high reflectance value.

A-3 PETROLOGY OF COAL

A-3.1 During coalification, the most important phenomenon which occurs along with the normal metamorphic carbonification is the development of petrographic entities. Microscopically these are composed of organic entities called macerals which are broadly divided into vitrinites, semi-vitrinites, liptinites and inertinites. Indian coals are usually marked by a notable petrographic heterogeneity in contrast to the coals occurring elsewhere in the world. The causes leading to such changes are fairly attributable to the differences in the original plant materials, the differences in the environmental conditions, etc. It is important to note that the different petrographic constituents possess different physical, chemical and structural characteristics. The properties of a given coal are an aggregate effect of these individual variations in addition to the changes due to the normal rank enhancement (adjudged on the main constituent, namely, the vitrinite in the coal).

A-3.1.1 Coals that are encountered in nature might at times undergo variations in their physical, chemical and structural properties due to, (a) weathering, and (b) the transverse of igneous intrusive. It may be mentioned that weathering is a natural oxidation process and this leads to lowering of calorific value. Where the original coal is caking, decrease of or even total loss of caking propensities may occur. Igneous intrusive produces a 'heat altered'/*Jhama* coal with loss of volatile matter. While a low rank coal may, at times, turn out to be caking but usually caking coals loose their caking propensity as a result of such heating. A complete *Jhama* may run down to as low as 4 to 5 percent volatiles (dry ash free basis, dmf) in the material.

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