IS 9127-1 (1992): Methods of Petrographic Analysis of Coal, Part 1: Definition of Terms Relating to Petrographic Analysis of Coal [PCD 7: Solid Mineral Fuels]

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(Reaffirmed 1998)

भारतीय मानक

कोयले के सजातीय शैल विश्लेषण की पद्धति

भाग 1 कोयले के सजातीय शैल विश्लेषण से सम्बन्धित पारिभाषिक शब्दों की परिभाषा

(पहला पुनरीक्षण)

Indian Standard

METHODS OF PETROGRAPHIC ANALYSIS OF COAL

PART 1 DEFINITION OF TERMS RELATING TO PETROGRAPHIC ANALYSIS OF COAL

(First Revision)

UDC 662·66 : 543·552·1 : 001·4

BUREAU OF INDIAN STANDARDS
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Price Group 2

FOREWORD

This Indian Standard (First 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 issued in 1979. The Committee responsible for its preparation reviewed in the light of the International Standard and the International handbook of coal petrography published by ICCP and decided to incorporate some modifications in order to update the same.

Petrographic analysis have been recognized internationally as important in the context of the genesis, vertical and lateral variation, continuity, metamorphism and usage of coal. Micropetrographic studies of an individual coal provide rich information about maturity (rank) of a coal along with its maceral *vis-a-vis* mineral distribution. The reflectance of vitrinite is a useful measure of coal rank and distribution of reflectance of vitrinite along with its maceral group analysis can give information about the different chemical and technological behaviour of the coal.

Coal is an organic sedimentary rock, the physical, chemical and technological properties of which depend upon its composition and its rank, that is, degree of metamorphism. It is derived from plant material and its composition is controlled by the nature of the deposited plant from which it was formed as well by its condition of deposition. Like most rocks, coal can be divided into several microscopically recognizable rock types, called lithotypes. When examined microscopically these rock types can further be subdivided into different identifiable entities, called macerals, that define and control the coal types.

The methods for the petrographic analysis of coal are covered in the following parts:

Part 1 Definition of terms

Part 2 Preparation of coal samples for petrographic analysis

Part 3 Determination of the maceral group composition of bituminous coal and anthracite

Part 4 Determination of microlitho type composition of bituminous coal (*under preparation*)

Part 5 Microscopical determination of the reflectance of vitrinite

In formulating this standard, due consideration has been given to international co-ordination among the standards and practices prevailing in different countries in addition to those relating to the practices in the field in this country. ISO 7404/1 : 1984 'Methods for the petrographic analysis of bituminous coal and anthracite — Part 1 : Glossary of terms', issued by the International Organization for Standardization (ISO) and also from the experience derived from the cooperative work of the Central Fuel Research Institute (CSIR), Dhanbad, the Indian School of Mines, Dhanbad, etc.

Indian Standard

METHODS OF PETROGRAPHIC ANALYSIS OF COAL

PART 1 DEFINITION OF TERMS RELATING TO PETROGRAPHIC ANALYSIS OF COAL

(First Revision)

1 SCOPE

1.1 This standard (Part 1) explains and defines the terms that are used in connection with the determination of the maceral group composition of coal in reflected white light and the determination of the reflectance of vitrinite.

1.1.1 The nomenclature and methods relating to fluorescence microscopy of coals and terms relating to the petrographic analysis of peat or lignite are not covered in this standard.

1.1.2 This standard is neither intended to be a comprehensive glossary of coal petrographic terminology, nor does it attempt to extend sufficient information to allow recognition of all the coal components described. In this regard detailed information may be obtained from the International Handbook of Coal Petrography.

2 NORMATIVE REFERENCES

The following standards contains provisions which through reference in the 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 agreement based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards listed below:

IS No.	*Title*
9127 (Part 2) : 1979	Methods for petrographic analysis of coal: Part 2 Preparation of coal samples for petrographic analysis
9127 (Part 5) : 1986	Methods for petrographic analysis of coal: Part 5 Microscopical determination of the reflectance of vitrinite

3 DEFINITIONS

3.1 General Terms

3.1.1 *Coalification*

The process by which the original sedimented compacted plant remains are transformed from peat into lignite and subsequently into coal by metamorphism.

NOTE — This process is characterized by the enrichment of the carbon content of the substance and the diminution of the oxygen contents. With increasing coalification, volatile matter content decreases and reflectance of the vitrinite increases. Since peat, lignite and bituminous coal represent successive stage of progressively higher rank in a transition series, there are no natural boundaries between the stage that have general application, although arbitrary limits may be applicable in individual coal basins.

3.1.2 *Peat*

It is an unconsolidated, carbonaceous sediment of high moisture content formed by the accumulation of partly decomposed plant remains.

NOTE — Peat deposits may become buried and consolidated and transformed into lignite or coal by the process of coalification (*see* 3.1.1).

3.1.3 *Lignite*

Lignite is a combustible, carbonaceous sedimentary rock formed from peat by diagenesis and metamorphism. Megascopically it is brown, dull and partly earthy. While under the microscope it has large pore volume and open cell lumens and its gelification is rare.

3.1.4 *Coal*

It is a combustible carbonaceous sedimentary rock formed from altered plant remains under the influence of temperature and pressure.

3.1.5 *Coal Rank*

Coal rank is the stage of coalification reached by a given coal. The rank of a coal is not a directly measurable quantity. To define it, it is necessary to refer to a specific physical or chemical property which exhibits change during the course of coalification, for example, reflectance of the vitrinite, carbon content, volatile matter content, etc.

NOTE — The properties of the different coal maceral change according to different patterns with increase in coal rank and so ideally it is preferably to determine rank on one particular maceral. Vitrinite is the best reference maceral because its characteristics change continuously with the course of coalification. It is an abundant constituent of most of the coals.

3.2 Optical Terms

3.2.1 *Reflectance*

Reflectance of a polished plane surface is expressed

as percentage of normally incident light which is reflected from that surface. Reflectance is dependent upon the refractive and absorptive indices of the component and the refractive index of the surrounding medium. The reflectance measurement is normally carried out at wavelength of 546 nm.

NOTE — Since other factors, such as the wavelength of the light being reflected and the quality of surface polish also influence the result, reflectance is measured under carefully specified conditions [*see* IS 9127 (Part 2) : 1979 and IS 9127 (Part 5) : 1986]. Since vitrinite usually behaves optically as a uniaxial negative crystal exhibiting anisotropy, measurements of either maximum reflectance [abbreviated as *R. (Max)*] or random reflectance [abbreviated as *R (r)*] may be made. Maximum reflectance is measured using plane polarized light, the specimen being rotated until the maximum reflectance is observed. Random reflectance is measured with the polariser removed and without rotation of the specimen. The term *'random reflectance'* has replaced the term *'average reflectance'* to avoid any possible confusion arising from the meaning of the word *'average'* in the mathematical sense.

3.2.2 *Parasitic Reflection*

The percentage of the incident light reaching the photomultiplier from lens boundary faces and other reflecting surfaces in the microscope.

3.2.3 *Reflectance Standard*

A polished surface of a material (usually glass) of known reflectance which is used for calibrating reflectance measuring equipment.

NOTE — It is essential that the reflectance standard meets stringent requirements with regard to the properties of the material of which it is composed, and the way in which it is mounted and prepared. The detail of this is described in IS 9127 (Part 5) : 1986.

3.2.4 *Zero Standard*

A non-reflecting standard used for calibrating reflectance measuring equipment.

3.2.5 *Specimen Block*

Coal specimen to be studied. This may be in the form of a polished block, a solid block impregnated with a binder (either araldite or carnauba wax) before polishing or a briquette of particles of crushed coal representative of the sample using a binder before polishing [*see* IS 9127 (Part 2) : 1979].

3.3 Petrographic Terms

3.3.1 *Macerals*

Macerals are the microscopically recognizable individual organic constituents of coal, parts evolved from the different organs and tissues of the plants from which the coal was originally formed by the process of coalification.

NOTE — Macerals of coal are analogous to the minerals of inorganic rocks, but differing from them in that macerals have no characteristic crystal from and are not constant in chemical composition. They are differentiated from one another microscopically on the basis of their differences in properties like colour, reflectance, morphology, etc.

3.3.2 *Sub-maceral*

A sub-division of a maceral based on slight morphological and physical differences.

NOTE — Information on the description and properties of the macerals and submacerals may be obtained by reference to the International Handbook of Coal Petrography.

3.3.3 *Maceral Group*

Macerals may be classified at several levels of discrimination depending upon the requirements of analysis. For many applications classification into broad, genetically related groups with similar properties is adequate. Three group macerals are recognized from Indian coals, these are vitrinite, exinite and inertinite (*see* **4.1**).

3.3.4 *Vitrinite*

The term embraces a group of macerals [*see* **3.3.4(a)** to **(d)**] derived from the original cell tissues (wood, periderm, etc) of the plants from which the coal was formed.

NOTE — Vitrinite commonly exhibits the morphology of the plant cells from which it was derived, but vitrinite macerals originating from the degradation or gelification of cell tissues may have a communited or amorphous appearance. Macerals of the vitrinite group typically have a grey/white colour in reflected light. Normally, reflectance increases continuously with increasing rank. It is the major component of most coals.

a) *Telinite* — Cellular structures in vitrinite are sometimes visible under microscope, particularly in low rank coals. The cell walls are called telinite. The cell cavities are filled with collinite, or less frequently with resinite, mineral matter, etc. Pure telinite is rare.

b) *Collinite* — This term is derived from the Greek word 'Kolla' which means gel. Collinite is the structureless constituent of vitrinite. In vitrinite sowing structure, the cells are frequently filled with collonite, while the cell walls consist of telinite.

c) *Vitrodetrinite* — Vitrinite can occur in the form of detritus. These fragments mostly originate from plants or humic-peat particles which were degraded at a very early stage.

d) *Semi-Vitrinite* — Semi-vitrinite is a transitory component between vitrinites and semifusinites of the intertinite group (*see* Table 1). It shows very fine cell structures or may even sometimes structureless and has a reflectance value of about 0.2 to 0.3 percent higher than that of the associated vitrinites.

NOTE — In the International maceral classification system, semi-vitrinite is not being considered as a separate maceral group or counted separately as a maceral. But as Indian Gondwana coals contain substantial amount of this component, therefore, this maceral has been considered as a distinct group by itself and counted separately for all practical purposes.

3.3.5 *Exinite*

a) *Sporinite* — The term 'sporinite' is used to designate the skins of spores and pollens in coal. There are two types of sporbodies e.g. Mega — and Microscopes. In low rank coals the sporinite looks dark and with increasing rank it changes to dark grey. The grayness becomes gradually paler and beyond 1.30 reflectance there is no longer any difference between the grey of sporinite and that of vitrinite.

b) *Cutinite* — In reflected light the outer layers (cuticles) of the leaves in coal are easily distinguishable by their shape, colour or brightness. The cuticles appear as small or wide bands with or without appendages.

c) *Resinite* — In coals, resinites appears mostly as cell fillings but can also occur as layers or finely dispersed. In vertical section resinite bodies usually appear as small spherical, oval or spindle shaped bodies or as rodlets. It occurs sometimes as fillings of microfissures and voids as it is very fluid.

d) *Alginite* — It is a maceral which only occurs in certain specific coals. It is rarely round in normal humic coals. It can easily be distinguished from the other macerals of the exinite group by the fact that it appears quite dark on polished surfaces under oil immersion, but because of their extremely low reflectance values close to those of clay minerals they may be mistaken either as mineral matter or even empty spaces in the coal matrix. However, using fluorescent light undoubtedly its identification is easier.

e) *Liptodetrinite* — It is a collective term for exinite (liptinite) microcomponents or different from Liptodetrinite may consist of fragments or degradation residues of spores, cuticles, resinous bodies or algae. These components, with low reflectance and fluorescence, because of their finely detrital condition, cannot be assigned with certainty to any of the other macerals of the exinite group.

3.3.6 *Inertinite*

a) *Fusinite* — A distinction is made between two types of fusinite on the basis of their origin viz. pyro-fusinite and degradofusinite. Both types occur in peat as well as in brown coals. They are particularly common in bituminous coals. Their usually prominent cellular structure and yellowish colour allows pyrofusinite to be distinguished from white cegracofusinite which has less well preserved cellular structure. Pyrofusinite shows strong relief in polished surfaces, in contrast to the weak to very weak relief of the other variety. The cell lumens are normally void, in some cases they are filled with mineral matter. In many cases the cell walls of pyrofusinite have been fractured and pushed into one another, forming in 'bogen' structure.

b) *Semifusinite* — It is a transitional material between fusinite and telinite. It always shows lower reflectance than fusinite and is of light yellowish or white colour. Its reflectance varies within wide limits.

c) *Macrinite* — It is more or less amorphous, non-granular ground mass of high reflectance showing no, or practically no structure. Apart from macrinite occurring as ground mass, there also occurs variably sized isolated macrinites with straight or, more commonly, rounded contours.

d) *Inertodetrinite* — It consists of strongly reflecting angular shaped fine broken/ crushed particles, normally less than 50 micron size, of fusinite, semifusinite, macrinite, etc.

e) *Micrinite* — It is characterized by rounded shape. The size of the grains are commonly about one micron across. The yellowish, pale grey to white micrinite does not show any relief and occur as cell fillings in vitrinite, but it frequently occurs finely dispersed in collinite.

f) *Sclerotinite* — The term 'sclerotinite' is derived from the Greek word 'scleros' which means hard, rigid, brittle. The term 'sclerotinite' covers all strongly reflecting fungal remains, such as hyphae, mycelia, plechtenchyma, spores and sclerotia.

3.3.7 *Mineral Matter*

Mineral matter is the inorganic matter that has become associated with the organic plant material during its genesis and subsequent coalification. They may be derived from the inorganic constituents of the plants themselves, or from the incorporation of minerals with the plant material during deposition. The microscopic appearance of the mineral matter will vary depending on the individual minerals present.

NOTE — Extraneous mineral matter introduced during mining and coal preparation may also be present in a sample.

4 CLASSIFICATION OF MACERALS

4.1 Macerals

Three maceral groups are recognized (*see* **3.3.3**). Maceral groups and their sub-divisions are shown in Table 1.

Table 1 Maceral Groups and Their Subdivisions

(*Clauses* 3.3.4 *and* 4.1)

Maceral Group Inertinite	Maceral Fusinite	Submaceral, Pyrofusinite, Degradofusinite
(1)	(2)	(3)
Vitrinite	Telinite	Telinite
	Collinite	Telocollinite Gelocollinite Desmocollinite Corpocollinite
	Vitrodetrinite	
	Semi-vitrinite	
Exinite	Sporinite Cutinite Resinite Alginite Liptodetrinite	
Inertinite	Semifusinite	Pyrofusinite
	Fusinite	Degradofusinite
	Micrinite Macrinite Sclerotinite Inertodetrinite	

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