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Assessment specification of coalbed methane resources

Spécifications d'évaluation des ressources en méthane de houille

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Foreword

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This document was prepared by Technical Committee ISO/TC 263, *Coalbed methane (CBM)*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Assessment specification of coalbed methane resources

1 Scope

This document specifies the objectives, tasks, work processes, classification, report preparation and acceptance of coalbed methane (CBM) resource evaluation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18871, *Method of determining coalbed methane content*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
coalbed methane
CBM
methane-rich gas naturally occurring in coal seams (and surrounding rock) typically comprising of 80 % to 95 % methane with lower proportions of ethane, propane, nitrogen and carbon dioxide

Note 1 to entry: In common international use, this term refers to methane recovered from un-mined coal seams using surface boreholes.

[SOURCE: ISO 18875:2015, 2.1]

3.2
CBM abundance
amount of hydrocarbons in unit area

[SOURCE: ISO 18875:2015, 2.28, modified — “resource” has been deleted from the term.]

3.3
CBM content
volume of hydrocarbon gas per unit mass of coal, usually expressed in cubic metre of gas per tonne of coal under standard temperature and pressure (STP) conditions

Note 1 to entry: The unit is m^3/t or cm^3/g. STP conditions are 100 000 Pa and 0 °C (273,15 K).

[SOURCE: ISO 18875:2015, 2.5]

3.4
resource
quantities of petroleum, recoverable and unrecoverable, that are estimated to exist originally in naturally occurring accumulations, discovered and undiscovered, plus those quantities already produced

3.5
reserves
quantities of petroleum anticipated to be commercially recoverable by application of development projects to known accumulations from a given date forward under defined conditions

4 General principles

4.1 Objective

The objective of the evaluation is to understand the distribution of CBM and the basic geological characteristics of CBM reservoirs in the evaluation region, locate the CBM exploration targets, evaluate the total amount, quality and certainty of CBM resources, lay a foundation for submitting a CBM reserves report, and provide a basis for prospective planning of CBM exploration and development.

4.2 Basic requirements

4.2.1 The evaluation work shall be conducted and submitted independently.

4.2.2 The relevant data collected shall be reliable, representative and consistent. The data quality shall meet the requirements of various professional specifications.

5 CBM resource evaluation workflow

5.1 General

The workflow of resource evaluation mainly includes data collection and collation, geological condition analysis, evaluation method selection, input parameters value assignment, resource calculation, and resource classification and conclusions.

5.2 Data collection and collation

5.2.1 Geophysical data

The interpretation results of gravitational, magnetic, electric and seismic data in the evaluation region shall be fully used to analyse the characteristics of faults, stratum distribution and coal seam burial depth, and to predict the control on CBM accumulation by faults, roof and floor conditions and the variation trend of coalbed thickness.

5.2.2 Regional geological data

Regional geological data includes:

a) regional geographical data (including geographical location, topography, rivers, natural resources, and major events such as earthquakes);

b) regional geological data and research achievements (including rocks, strata, structures, minerals, crustal movement and development history);

c) hydrogeological survey data (including general status of groundwater resources; lithology and distribution of aquifers; genesis, types, recharge and discharge conditions of groundwater; distribution of water quality and quantity; division of hydrogeological units);

d) relevant information of extraction in the adjacent regions (including CBM resources, exploration and development, dewatering and production, ground water extraction and gas production);

e) coalfield exploration reports and maps (including geological exploration reports compiled at different exploration stages, final reports and maps);

f) coal mining data (including shaft development and mining design, mining roadway layout, shaft reserves, production capacity and service life).

5.2.3 Drilling data

5.2.3.1 Mud logging data

Mud logging includes cuttings logging, drilling time logging, coring and gas logging. The deliverables include a comprehensive mud logging curve and a gas logging map.

5.2.3.2 Wireline logging data

The conventional wireline logging series to be used includes deep or shallow laterolog, microsphere focus logging, compensated density log, compensated neutron log, compensated acoustic log, natural potential log, natural gamma log and dual calliper log in CBM development.

The unconventional wireline logging series to be used includes acoustic imaging log, resistivity imaging log and nuclear magnetic resonance (NMR) imaging log in CBM development.

5.2.3.3 Well testing data

Fall-off testing in injection wells is generally conducted.

5.2.4 Laboratory test data

Laboratory test data mainly includes core description, coal structure analysis, bulk density, macerals of coal, proximate analysis of coal, elemental analysis, vitrinite reflectance, gas composition, gas content, and isothermal adsorption test. See Table 1 for the results and application for each item.

Table 1 — Laboratory test data summary

Item	Uses
Core description	To understand macroscopic coal rock characteristics and coal structure.
Bulk density	Key parameter to calculate coal and CBM resources/reserves.
Macerals of coal	To qualitatively reflect the gas content and permeability of the coal.
Proximate analysis	To correct the gas content and adsorption isotherm, and determine the coal maturity and coal quality.
Elemental analysis	To determine the percentage of oxygen, carbon, hydrogen, sulfur and nitrogen, and evaluate the maturity of coal.
Vitrinite reflectance	To determine the coal rank.
Gas composition	To determine the percentage of CH_4, CO_2, N_2, and C_2H_6. It is mainly used to determine the purity of the gas.
Gas content	Key parameter to calculate CBM resources/reserves.
Isothermal adsorption test	To describe how much gas can be stored in a coal seam and how fast it will be released.

5.3 Geological conditions analysis

5.3.1 Determination of exploration degree

The exploration degree of the evaluation region shall be determined according to the in-depth analysis of coal field exploration, CBM exploration data and coal production status.

5.3.2 Geologic map compiling

On the basis of data collection, collation and analysis, the basic geologic maps shall be compiled for the evaluation of CBM resources, such as coal seam structure contour map, coal seam burial depth map, coal seam isopach map, stratigraphic correlation profile and CBM gas content map.

5.3.3 Comprehensive analysis

The geological condition analysis includes the regional tectonic characteristics, sedimentary characteristics, strata and coal seam distribution, coal characteristics and coal rank, coal reservoir characteristics (porosity, permeability, gas content, temperature, pressure, etc.), rock characteristics of the roof and floor of coal seam and hydrogeological characteristics. They provide a geological basis for the evaluation methods selection and key parameters value assignment.

5.4 CBM resource calculation

5.4.1 General

The volumetric method shall be used for resource calculation if there is adequacy of geological data which meets requirements of the calculation.

5.4.2 Principles for input parameters value assignment for volumetric method

5.4.2.1 General requirement

The input parameters used in the resource calculation shall be prudently verified on the basis of comparing their accuracy and representativeness, and the principles for value assignment shall be briefly described in the resource evaluation report.

5.4.2.2 Value assignment principles for gas-bearing area

“Gas-bearing area” refers to the region of coal seam distribution in the resource evaluation region. Geological, drilling, logging, seismic and coal sample test data shall be fully utilized to comprehensively analyse the geometrical dimensions of coal seam distribution.

The boundary of the CBM reservoir shall be identified by fault, pinch, erosion, effective thickness of coal seams cut-off, gas content cut-off, gas weathering, spontaneous combustion or goaf.

The boundary of the mineral right and the natural geographical boundary shall also be considered.

5.4.2.3 Value assignment principles for effective thickness of coal seams

The effective thickness of the coal bed refers to the thickness of coal seams minus the gangue layer, also known as the “net thickness”. It can be determined by coring data or by electrical property cut-off of the coal seam.

The effective thickness of coal seams cut-off should be 0,5 m. Any individual seam with thickness (with gangue layer thicker than 0,1 m deducted, if any) less than 0,5 m shall be ignored.

The area-weighted average thickness taken by the area trade-off method shall be used.

5.4.2.4 Value assignment principles for coal density

The arithmetic average density of all coal samples measured in the laboratory shall be used.

5.4.2.5 Value assignment principles for CBM content

The CBM content of coal samples shall be determined in accordance with ISO 18871.

In the laboratory, the gas content of coal shall be reported on a dry ash-free basis or an ash-free basis, and its conversion relationship can be estimated by using Formula (1):

$$C_{ad} = C_{daf}(1 - M_{ad} - A_{ad}) \tag{1}$$

where

C_{ad} is the gas content of coal on an air-dried basis, expressed in cubic metres per tonne (m^3/t);

C_{daf} is the gas content of coal on a dry ash-free basis, expressed in cubic metre per tonne (m^3/t);

M_{ad} is the residual moisture content on an air-dried basis, expressed in percentage (%);

A_{ad} is the dry ash content on an air-dried basis, expressed in percentage (%).

The cut-off of gas content on an air-dried basis should be 1,0 m^3/t. It can be adjusted according to a different coal rank and, with the increase of coal rank, the cut-off of gas content can be increased appropriately.

The area-weighted average content of all coal samples taken by the area trade-off method shall be used.

5.4.3 Volumetric method for CBM resources

Volumetric method is the basic method for the calculation of CBM resources. The accuracy of the method depends on the understanding of the geological conditions of gas reservoirs and the accuracy of the input parameters.

If coal resources data are available, CBM resources can be calculated by using Formula (2):

$$G_i = G_c C_{ad} \tag{2}$$

where

G_i is the original CBM in place, expressed in million cubic metres (10^6 m^3);

G_c is the coal resources, expressed in million tonnes (10^6 t);

C_{ad} is the gas content of coal on an air-dried basis, expressed in cubic metres per tonne (m^3/t).

If coal resources data are not available, according to the input parameters on a dry ash-free or an ash-free basis, CBM resources can be calculated by using Formula (3) or (4):

$$G_i = AhDC_{ad} \tag{3}$$

$$G_i = AhD_{daf}C_{daf} \tag{4}$$

where

G_i is the original CBM in place, expressed in million cubic metres (10^6 m^3);

A is the gas bearing area of coal seam, expressed in square kilometres (km^2);

h is the effective thickness of coal seam, expressed in metres (m);

D is the mass density of coal on an air-dried basis, expressed in tonnes per cubic metres (t/m^3);

C_{ad} is the gas content of coal on an air-dried basis, expressed in cubic metres per tonne (m^3/t);

D_{daf} is the mass density of coal on a dry ash-free basis, expressed in tonnes per cubic metres (t/m^3);

C_{daf} is the gas content of coal on a dry ash-free basis, expressed in tonnes per cubic metres (t/m^3).

5.4.4 Evaluation method for CBM reserves

5.4.4.1 After obtaining an original CBM in place, the CBM reserves is simply an original CBM in place multiplied by the estimated recovery factor, as shown by Formula (5):

$$G_r = G_i \cdot R \tag{5}$$

where

G_r is the CBM reserves, expressed in million cubic metres (10^6 m^3);

G_i is the original CBM in place, expressed in million cubic metres (10^6 m^3);

R is the recovery factor, expressed in percentage (%).

There are several techniques to estimate the CBM recovery factor (R), as given in 5.4.4.2 to 5.4.4.4.

5.4.4.2 If production and pressure data of CBM wells from a field are available, a forecast gas production profile (rate versus time) can be obtained using decline curve analysis or reservoir simulation. Then, the CBM recovery factor (R) can be estimated by using Formula (6):

$$R = \frac{Q_{aw}}{G_{iw}} \tag{6}$$

where

Q_{aw} is the cumulative gas production from profile, expressed in million cubic metres (10^6 m^3);

G_{iw} is the well-controlled reserves, expressed in million cubic metres (10^6 m^3).

5.4.4.3 If adsorption isotherm is available, the CBM recovery factor (R) can be theoretically calculated based on the initial gas content and abandonment gas content (corresponding to reservoir abandonment pressure), as shown by Formula (7), or based on the initial gas content, abandonment pressure, Langmuir volume and Langmuir pressure from the isotherm, as shown by Formula (8):

$$R = \frac{C_i - C_a}{C_i} \tag{7}$$

$$R = 1 - \frac{V_L \cdot P_a}{C_i \left(P_L + P_a\right)} \tag{8}$$

where

C_i is the initial gas content, expressed in cubic metres per tonne (m^3/t);

C_a is the abandonment gas content, expressed in cubic metres per tonne (m^3/t);

V_L is the Langmuir volume, expressed in cubic metres per tonne (m^3/t);

P_L is the Langmuir pressure, expressed in megapascals (MPa);

P_a is the abandonment pressure, expressed in megapascals (MPa).