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Coal preparation — Determination of dust/moisture relationship for coal

Préparation du charbon — Détermination de la relation particules/humidité du charbon

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 27, *Coal and Coke*, Subcommittee SC 1, *Coal preparation: Terminology and performance*.

This second edition cancels and replaces the first edition (ISO 20905:2004), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— the title of ISO/TC 27 was changed from "Solid mineral fuels" to "Coal";

— some terminology was changed to align with ISO rules, for example the terms "percentage", "weight" and "weighing".

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.

Introduction

The development of the dust/moisture curve provides an indication of the likely response of different coal types to drying or water addition during mining and handling processes. The dust/moisture curve provides a good basis for comparing the response of different coal types. Understanding the dust/moisture characteristics of a coal allows minimized water addition to the product for dust suppression. This in turn assists in water conservation at mines and other handling facilities, as well as minimizing the total moisture of the product.

This document describes a reliable measurement of dustiness of coal and extends to cover the relationship between dust and total moisture utilizing the Rio Tinto Dust Tumbler Test. This test provides a quantitative measure of the dustiness of a coal that can be used to predict operational dust problems and is also suitable for the assessment of dust suppression chemicals.

The Rio Tinto Dust Tumbler Test was developed using rotating equipment in a controlled temperature and humidity environment and uses a stream of air to remove particles which become airborne during the tumbling process. It is a batch test in which dust particles (–150 µm particles) are collected in a filter bag of known mass and their mass is determined. From this mass, a dust number, calculated as the mass yield of dust multiplied by 100 000, is determined for the test total moisture. Only 1 kg of sample is required for each dust test, but eight sample lots are required to develop the dust/moisture curve for a particular coal, i.e. approximately 10 kg is required for each coal type.

This dust test can be repeated with subsamples at different coal total moisture levels to develop a dust/moisture curve. The slope of the curve provides information on how sensitive the dustiness is to changes in total moisture and a dust number of 10 has been used to provide a comparison between coals.

The test has been successfully used for several years on many coals and other bulk materials. The results have been correlated with the operating practice. The method has been applied to the evaluation of dust-control products and the determination of dust-elimination total moisture requirements for coal-handling systems.

Coal preparation — Determination of dust/moisture relationship for coal

1 Scope

This document sets out a laboratory procedure for the dust testing of higher rank coals. The procedure defines a means of evaluating the dust/moisture relationship characteristic of a coal and a dust extinction moisture (DEM).

NOTE In this document, an experimental dust number of 10 has been used in the example given in Annex A.

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 589, Hard coal — Determination of total moisture

ISO 7886-1, *Sterile hypodermic syringes for single use — Part 1: Syringes for manual use*

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
dust
particles of size 150 µm or less entrained in an air stream

3.2
dust extinction moisture
DEM
total moisture at which a dust number of 10 is attained on the dust/moisture curve

Note 1 to entry: DEM is a useful point for comparing different coals and the effectiveness of reagents.

4 Safety

The following safety precautions shall be observed:

— To prevent nitrogen build-up within the laboratory, the exhaust tube of the minimum-free-space oven shall remain clear of obstruction.

— Safety glasses shall be worn at all times.

— The exhaust tube of the minimum-head-space oven shall remain free of obstruction to prevent nitrogen build-up within the laboratory.

— A dust mask shall be worn when handling coal.

— Cloth or leather gloves shall be worn when using ovens.

— The hazards associated with a reagent shall be determined prior to use. Instructions on all relevant material safety data sheets shall be followed.

5 Apparatus and equipment

The following apparatus and equipment is required.

5.1 Humidity- and temperature-controlled laboratory, with relative humidity of 63 % ± 2 % and temperature of 20 °C ± 2 °C.

5.2 Dust-test apparatus, with a rotating drum of 30 cm diameter and 30 cm effective length, as shown in Figure 1. The required drum speed is 29 r/min, and the desired airflow through the drum is 175 L/min.

5.3 Double filter bags, single use only.

5.4 Electronic thermohydrograph.

5.5 Tachometer.

5.6 Laminar flow differential-pressure manometer.

5.7 Stopwatch.

5.8 Capped bottles, of capacity 250 mL, wide mouth, polypropylene.

5.9 Top loading balance, which has a minimum capacity of 1 g and is readable to the nearest 0,01 g.

5.10 Laboratory trays.

5.11 Minimum-free-space drying oven.

6 Reagent

Tap water is used in solution and sample preparation.

7 Sample — Initial

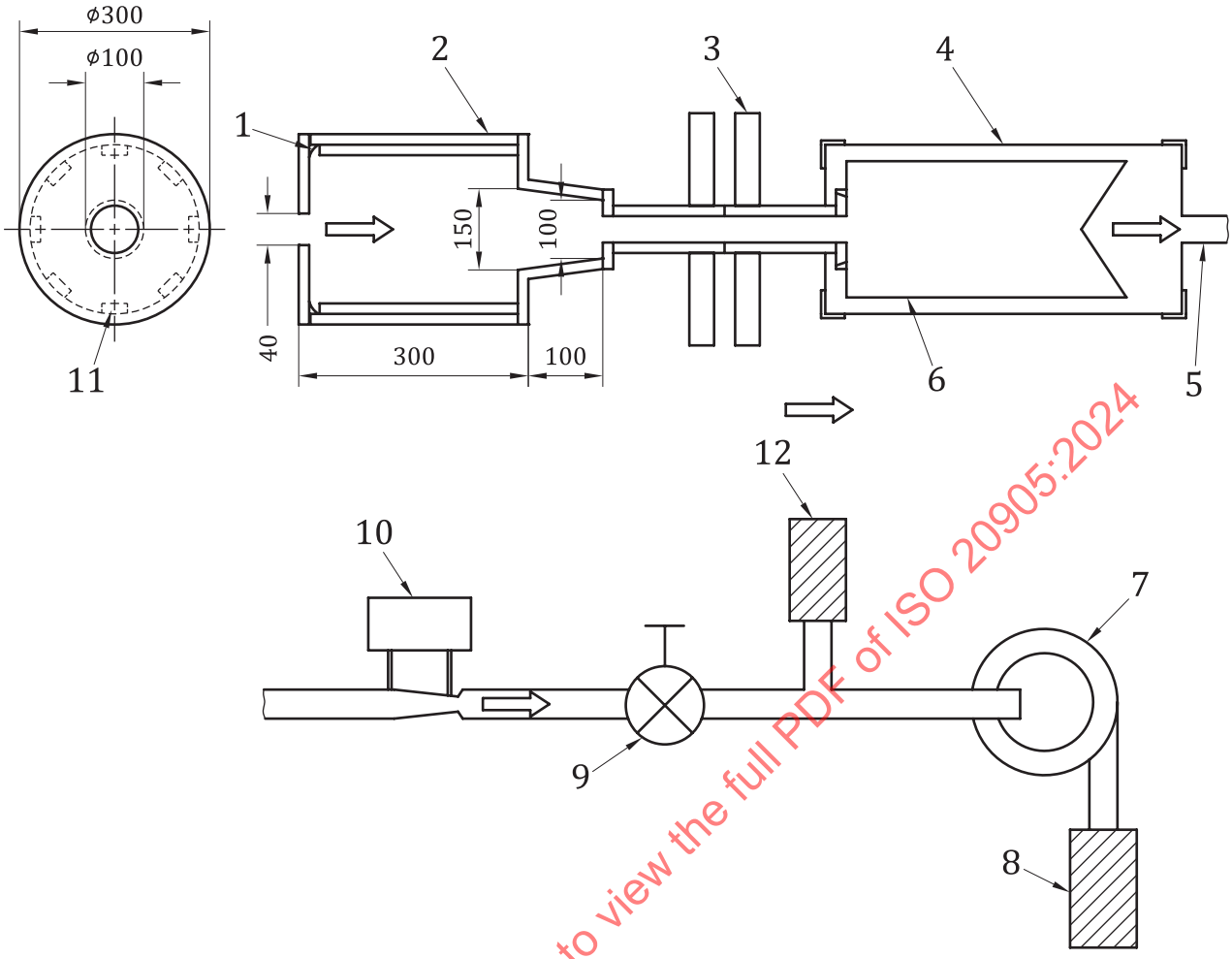
Before testing, remove the particles greater than 6,3 mm. Do not crush and replace this removed fraction as the sample's particle size distribution will be altered.

Prepare sufficient sample to provide 1,2 kg for each dust determination over the desired range of total moisture or reagent concentrations as well as 1,2 kg for sample characterization. Approximately eight subsamples, using a range of total moisture values, are required to develop a dust/moisture relationship.

Once the sample has been screened, it shall be representatively split down to approximately 1,2 kg portions which are then heat-sealed in plastic bags and labelled.

One of the 1,2 kg portions is used to determine the sample's total moisture mass fraction (initial total moisture), particle size distribution as specified in ISO 1953, and other relevant characteristics. The experimental details relating to these properties shall be recorded and retained.

Dimensions in millimetres



Key

1	rubber seal	7	blower
2	rotating drum	8	muffler
3	drive unit, 30 r/min	9	valve
4	sealed compartment with hinged lid for bag access	10	flowmeter, 170 L/min
5	25 mm flexible hose	11	lifters 7 mm wide, 6 mm high
6	vacuum bag	12	intake

Figure 1 — Dust-test apparatus

8 Sample preparation — Initial

8.1 Initial total moisture

Determine the initial total moisture, M_1, of the sample using a subsample of the extra 1,2 kg lot, as specified in ISO 589.

8.2 Moisture adjustment

Samples are moisture adjusted to produce a range of total moisture mass fractions at approximately 1 % moisture intervals. Adjust the total moisture of each of the 1,2 kg subsamples to the required level for dust testing via the following processes:

a) For samples requiring total moisture mass fractions greater than the initial total moisture, M_1, water is added to the samples. Determine the sample mass and calculate the mass of water required, W_a, to achieve the required total moisture mass fraction, M_2, using Formula (1):

$$W_a = m_2 - m_1 \quad (1)$$

where

W_a is the water addition (or removal) required, expressed in g;

m_1 is the sample mass (at M_1), expressed in g;

m_2 is the sample mass (at M_2), expressed in g.

Add the required mass of water via a spray bottle to the subsample in the plastic bag on an electronic balance. Reseal the bag and shake the bag to assist with water distribution. Leave the sample in the temperature- and humidity-controlled room (5.1) for 24 h to equilibrate. Calculate the mass required, m_2, using Formula (2):

$$m_2 = m_1 \times \frac{100 - M_2}{100 - M_1} \quad (2)$$

where

M_1 is the initial total moisture mass fraction (as measured in 8.1), expressed in per cent;

M_2 is the required total moisture mass fraction, expressed in per cent;

b) For samples requiring total moisture mass fractions less than the initial total moisture, M_1, water is removed by low-temperature drying. The material shall be evenly dried. Determine the sample mass and calculate the mass of water loss required to achieve the required total moisture level, using Formula (1) and Formula (2). Place the sample in a tray in the controlled-environment laboratory and allow the sample to dry to the required mass. The mass of the tray should be determined periodically until the required mass of water is removed. Return the sample to the plastic bag, seal and leave to equilibrate for 24 h prior to dust testing. If the required mass loss cannot be achieved at the laboratory conditions, the sample may be dried to the required moisture mass fraction in a 40 °C oven, and then equilibrated in a sealed bag in the laboratory for 24 h.

9 Sample preparation — Reagent

Reagents can be added in addition to, or instead of, water. If the reagent is an aqueous solution, the coal sample is moisture adjusted such that the addition of a reagent increases the total moisture mass fraction to the target. Reagent doses are normally based on µg/g per mass of dry coal.

The adjusting procedure should be as follows:

a) Prepare the reagent according to the manufacturer's instructions.

b) Adjust the sample mass to just below the required total moisture mass fraction, using one of the methods described in 8.2, allowing for any water addition associated with the reagent dosing.

c) Scoop and brush coal into a mixer bowl and place in a mixer.

d) Determine the mass of the final moisture addition (reagent solution) and use a clean syringe in accordance with ISO 7886-1 to add the final moisture.

e) Run the mixer at low speed and start the stopwatch (5.7). Using the syringe, slowly pour the final moisture and reagent onto the coal over a period of 1 min, moving the syringe around the coal sample while pouring.

f) After 2 min, stop the mixer.

g) Brush coal off the mixer blade and into the centre of the mixer bowl.

h) Mix for a further 3 min.

i) Scoop and brush the coal sample into a new labelled plastic bag, then heat-seal it.

j) To allow the prepared sample to equilibrate, leave it in the heat-sealed bag for 24 h. The sample is then ready to dust test.

10 Dust determination

10.1 Environment and equipment checks

The following checks shall be undertaken:

a) Ensure that the laboratory atmosphere is within the specified conditions by using the thermohydrograph (5.4).

b) Ensure that the dust-test apparatus (5.2) is clean by blowing any residual particles from the piping and drum with compressed air.

c) With an unused filter bag (5.3) in place, ensure that the correct quantity of air is passing through the drum. (The desired air flow is 175 L/min. This is approximately equivalent to 3,5 m/s or 12,6 km/h.

d) Ensure that the drum rotation speed is correct, using the tachometer (5.5) and adjusting the motor position if necessary. The required drum speed is 29 r/min.

WARNING — Care must be taken when using compressed air for cleaning purposes.

10.2 Dust testing

Complete the following for each moisture-adjusted 1,2 kg sample:

a) Select a clean filter bag (5.3) that has been equilibrating at laboratory conditions for at least 24 h; label, record the mass on a worksheet to the nearest ±0,01 g and place it in the dust-test apparatus (5.2).

NOTE An example of a worksheet is given in Annex B.

b) Take duplicate samples for total moisture determination.

c) Take a representative sample of approximately 1 kg and determine its mass to the nearest ±0,01 g.

d) Place the sample in the drum, ensuring that all of the sample is in the lifter part of the drum only. Replace the end plate and guard mesh.

e) Start the fan.

f) When the fan has reached full speed, start the drum rotating and the stopwatch.

g) After 10 min, stop the drum motor.

h) Allow the fan to run for a further 13 s after stopping the drum motor.

i) Carefully, so as not to lose any dust, remove the filter bag (5.3) and record its mass. Leave the bag in a clean area of the humidity- and temperature-controlled laboratory (5.1) and redetermine its mass after 24 h.

j) Place a large tray (5.10) under the drum, remove the end plate and brush coal from the drum into the tray.

k) Take one subsample for the determination of final total moisture as a check reference, using the same method as used for the duplicate samples in Step b).

l) Complete total moisture determinations and record on a worksheet.

m) After 24 h, record the dust-bag mass for the final dust calculation.

Each subsample should be dust tested once only, i.e. samples are not to be retested as dust will have been lost during the first test.

Filter bags should be used once only and discarded.

11 Calculation

The result for the dust number, *N*, shall be calculated using Formula (3):

$$N = \frac{M_b - M_a}{M_s} \times 100\,000 \tag{3}$$

where

M_b is the mass of filter bag and dust 24 h after the dust test, expressed in g;

M_a is the mass of filter bag, expressed in g;

M_s is the mass of sample placed in drum, expressed in g.

12 Report

Report dust numbers to the nearest whole number, accompanied by their respective sample total moistures, as placed in the drum.

13 Precision

The reproducibility of the test is 10 % (relative), and errors in total moisture measurements are ±0,2 %, and in the dust number ±6 %.

Annex A
(informative)

Worked example

A.1 Scope

This Annex sets out a worked example of the calculation of the results of the testing in accordance with this document and provides an interpretation of the data.

A.2 Procedure

The dust-test procedure is repeated on several subsamples at a range of measured total moistures and a dust/moisture curve is developed. The data from the series of tests is recorded in a table such as Table A.1.

From the table, the dust number is plotted against the sample total moisture mass fraction. The final dust number (after 24 h equilibration) is plotted against the average total moisture measured prior to the test. The dust/moisture curve is plotted on a linear/log plot as shown in Figure A.1. An exponential trendline is fitted and the dust extinction moisture (DEM) determined at the example dust number of 10. For this example, the DEM is 8,8 % total moisture.

A.3 Interpretation of results

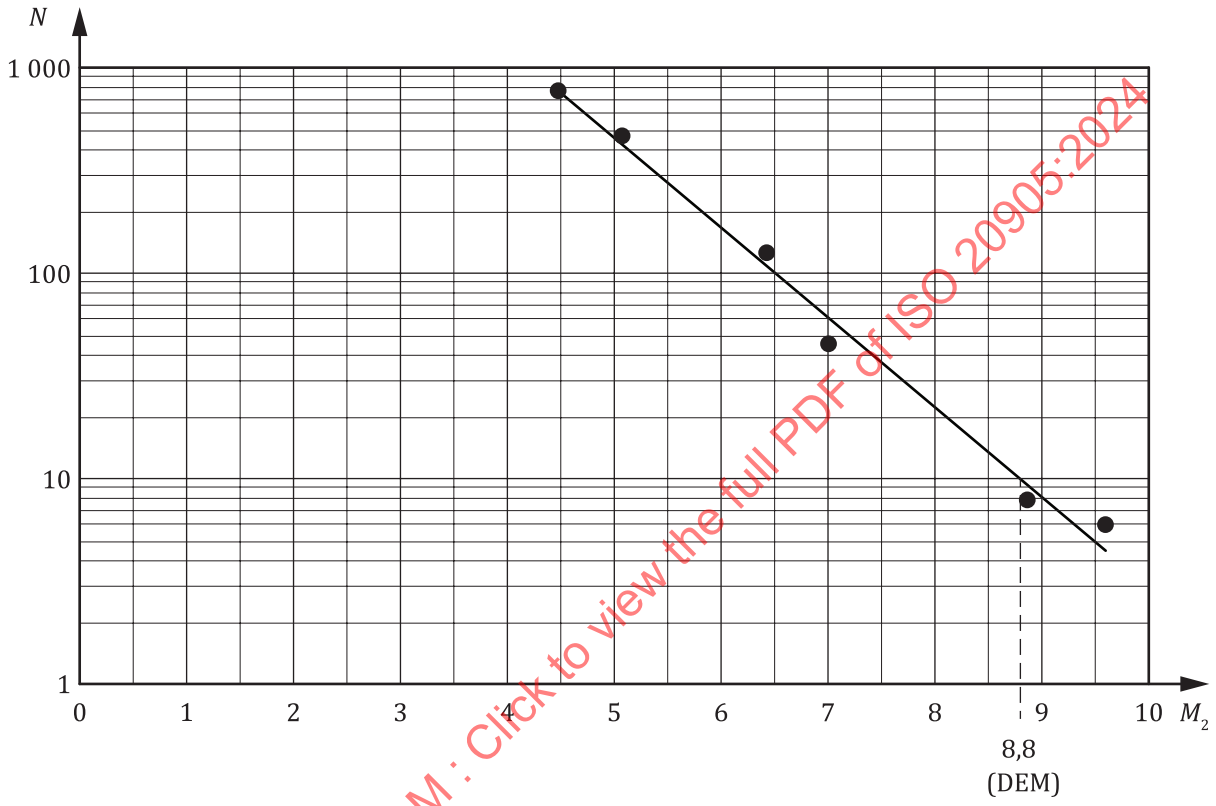
Figure A.2 shows several examples of dust/total moisture curves produced for various coals. The slope of the curve provides information on how sensitive the dustiness is to changes in total moisture mass fraction. For example, Coal A and Coal B show the same dust number of 1 000 at 8 % total moisture mass fraction. However, because of Coal B's increased sensitivity to moisture addition, as shown by the steep gradient of the dust/total moisture curve, the total moisture mass fraction required at a dust number of 10 is only 9 %, in comparison to the 14 % required by Coal A. From this, it can be concluded that Coal B would require less water addition to show a significant decrease in dustiness.

Table A.1 — Summary of dust-test results

Date	Sample	Tray no.	Wet sample mass	Tray + wet sample mass	Tray + dry sample mass	Moisture	Average moisture	Sample mass	Bag mass	(10 min) dust + bag mass	Prelim-in. dust number	(24 h) dust + bag mass	Final dust number
			g	g	g	%	%	g	g	g		g	
18-Dec-96	Initial	21	48,40	376,12	373,97	4,44	4,4	1 000,26	29,95	37,40	744,81	37,30	735
	Initial	22	48,43	359,60	357,45	4,44							
	Final	23	49,22	360,22	358,16	4,19							
18-Dec-96	Initial	30	48,65	359,76	357,28	5,10	5,1	1 000,38	29,93	34,65	471,82	34,51	458
	Initial	31	48,47	355,85	353,37	5,12							
	Final	32	48,48	356,88	354,53	4,85							
18-Dec-96	Initial	24	48,51	363,87	360,92	6,08	6,4	1 000,23	29,62	31,09	146,97	30,92	130
	Initial	25	48,28	361,37	358,09	6,79							
	Final	26	48,41	366,15	363,09	6,32							
18-Dec-96	Initial	27	48,27	355,43	351,91	7,29	7,0	1 000,73	29,33	29,90	56,96	29,76	43
	Initial	28	48,36	358,86	355,59	6,76							
	Final	29	48,22	362,17	358,68	7,24							
18-Dec-96	Initial	33	48,27	356,81	352,83	8,25	8,8	1 000,17	30,23	30,44	21,00	30,30	7
	Initial	34	48,27	365,46	360,92	9,41							

Table A.1 *(continued)*

Date	Sample	Tray no.	Wet sample mass g	Tray + wet sample mass g	Tray + dry sample mass g	Moisture %	Average moisture %	Sample mass g	Bag mass g	(10 min) dust + bag mass g	Prelim-in. dust number	(24 h) dust + bag mass g	Final dust number
	Final	35	48,82	360,88	357,09	7,76							
18-Dec-96	Initial	36	48,39	372,11	367,58	9,36	9,6	1 000,28	30,32	30,50	17,99	30,38	6
	Initial	37	48,37	377,23	372,48	9,82							
	Final	38	48,40	380,29	376,19	8,47							



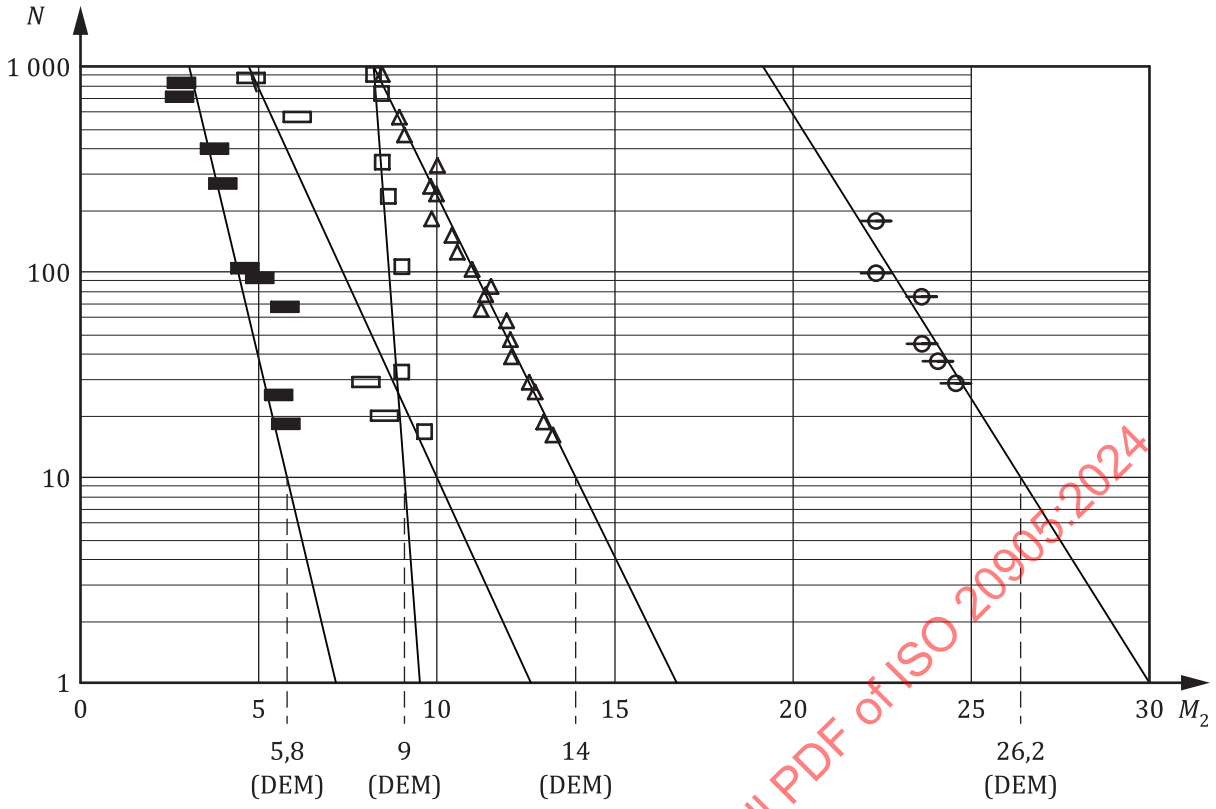
Key

N dust number

M_2 total moisture

DEM dust extinction moisture

Figure A.1 — Dust/moisture curve for a typical coal



Key

N	dust number
M_2	total moisture
DEM	dust extinction moisture
△	coal A
□	coal B
▬	coal C
⊖	coal D
▭	coal E

Figure A.2 — Dust/total moisture curves for several different coals

Annex B
(informative)

Worksheet example