BS ISO 1170:2013

BSI Standards Publication

Coal and coke — Calculation of analyses to different bases

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of ISO 1170:2013. It supersedes BS ISO 1170:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PTI/16, Solid mineral fuels.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 80381 9

ICS 73.040; 75.160.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 July 2013.

Amendments issued since publication

Date	Text affected

BS ISO 1170:2013

INTERNATIONAL STANDARD

ISO 1170

Third edition
2013-07-01

Coal and coke — Calculation of analyses to different bases

Charbon et coke — Calculs pour les analyses par rapport à différentes bases

Reference number
ISO 1170:2013(E)

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. www.iso.org/patents

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

The committee responsible for this document is ISO/TC 27, *Solid mineral fuels*, Subcommittee SC 5, *Methods of analysis*.

This third edition cancels and replaces the second edition (ISO 1170:2008), of which it constitutes a minor revision.

Coal and coke — Calculation of analyses to different bases

1 Scope

This International Standard gives equations that allow analytical data relating to coal and coke to be expressed on the various different bases in common use. Consideration is given to corrections that can be applied to certain determined values for coal prior to their calculation to other bases.

2 Normatives references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 602, *Coal — Determination of mineral matter*

ISO 17247, *Coal — Ultimate analysis*

3 Principle

In order to convert an analytical result expressed on one basis to another basis, it is multiplied by a factor calculated from the appropriate formulae (see Table 1) after insertion of the requisite numerical values.

4 Symbols

The symbols employed in the subsequent clauses are as follows, with suffixes (separated by a dot) “ad” (air-dried), “ar” (as-received), “d” (dry), “daf” (dry, ash-free) or “dmmf” (dry, mineral-matter-free) where appropriate.

w_A ash, expressed as percent mass fraction

w_C carbon content, expressed as percent mass fraction

w_{Cl} chlorine content, expressed as percent mass fraction

$w_{Cl.inorg}$ inorganic chlorine content, expressed as percent mass fraction

w_{CO2} carbon dioxide content, expressed as percent mass fraction

w_H hydrogen content, excluding hydrogen in the moisture, but including the hydrogen from water of hydration in minerals, expressed as percent mass fraction

w_{H2O} moisture content, expressed as percent mass fraction

w_h water of hydration in the mineral matter, expressed as percent mass fraction

w_{MM} mineral matter content, expressed as percent mass fraction (see Annex A)

w_N nitrogen content, expressed as percent mass fraction

w_O oxygen content, excluding oxygen in the moisture but including the oxygen from water of hydration in minerals, expressed as percent mass fraction

$w_{S,o}$ organic sulfur content, expressed as percent mass fraction

$w_{S,p}$ pyritic sulfur content, expressed as percent mass fraction

$w_{S,s}$ sulfate sulfur content, expressed as percent mass fraction

$w_{S,T}$ total sulfur content, expressed as percent mass fraction

w_V volatile matter content, expressed as percent mass fraction

F_{Cl} national correction factor for the estimation of the inorganic chlorine content

F_h national correction factor for the estimation of water of hydration

F_{MM} national correction factor for the estimation of the mineral matter (see Annex A)

5 Calculations for coal analyses

5.1 Introduction

In International Standards covering the analysis of coal, it is generally specified that the determination shall be carried out on an air-dried test sample. However, in making use of these analyses, it is sometimes necessary to express or report the results on some other basis. The bases in common use are “air-dried”, “as-received”, “dry”, “dry, ash-free”, and “dry, mineral-matter-free”.

5.2 Procedure

Any analytical value (except net calorific value) on a particular basis may be converted to any other basis by multiplying it by the appropriate factor calculated from the formulae given in Table 1, after insertion of the requisite numerical values for the symbols (for determination of moisture, see ISO 589 and ISO 11722; for ash, see ISO 1171). However, in some determinations, there is a direct involvement of the mineral matter and, in these cases, it is essential to apply a correction to the air-dried result prior to its calculation to the dry, mineral-matter-free basis. This correction is dependent on the nature, as well as the quantity, of the mineral matter present and, for any given sample, the formula recommended by the national standards organization of the country of origin of the sample should be used and should be quoted in full, together with the analysis. All the determinations that may be expressed on the dry, mineral-matter-free basis are considered individually below.

If it is necessary to calculate an analytical result expressed on the dry, mineral-matter-free basis back to any other basis, then it is essential that any correction deducted during the application of any Formulae (1) to (10) inclusive be added back to the dry, mineral-matter-free value before applying the appropriate formula from Table 1.

5.3 Carbon

Total carbon, as determined in coal, comprises both organic carbon and carbonate carbon in the mineral matter. It is reported on the air-dried basis (see ISO 609, ISO 625, or ISO 29541). In order to convert the total carbon content as analysed to a dry, mineral-matter-free basis, subtract the carbonate carbon before the conversion as given in Formula (1):

$$w_{C.dmmf} = (w_{C.ad} - 0{,}273\, w_{CO2.ad}) \times \frac{100}{100 - (w_{H2O.ad} + w_{MM.ad})} \quad (1)$$

5.4 Hydrogen

The hydrogen content reported on the air-dried basis includes the hydrogen of the coal substance and the hydrogen present (as water) in the mineral matter (see ISO 609, ISO 625 and ISO 29541). The hydrogen present as moisture in the air-dried sample shall be deducted before reporting $w_{H.ad}$. Before calculating

the hydrogen of the coal substance to a dry, mineral-matter-free basis, it is also necessary to deduct the hydrogen of the mineral matter as given in Formula (2):

$$w_{\mathrm{H.dmmf}} = (w_{\mathrm{H.ad}} - \frac{w_{\mathrm{h.ad}}}{9}) \times \frac{100}{100 - (w_{\mathrm{H2O.ad}} + w_{\mathrm{MM.ad}})} \tag{2}$$

Since the water of hydration in the mineral matter cannot readily be determined, it is generally estimated from a knowledge of the minerals likely to be present and the total mineral matter content as given in Formula (3):

$$w_{\mathrm{h.ad}} = F_{\mathrm{h}} \times w_{\mathrm{A.ad}} \tag{3}$$

where F_{h} is a national factor, depending of the actual type of coal. If no national factor is available, a value of F_{h} equal to 0,1 may be used to achieve an approximate result.

5.5 Nitrogen

The nitrogen content is reported on the air-dried basis (see ISO 29541). There is no nitrogen in the mineral state normally associated with coal, and the calculation to a dry, mineral-matter-free-basis is as given in Formula (4):

$$w_{\mathrm{N.dmmf}} = w_{\mathrm{N.ad}} \times \frac{100}{100 - (w_{\mathrm{H2O.ad}} + w_{\mathrm{MM.ad}})} \tag{4}$$

5.6 Sulfur

The total sulfur content, $w_{\mathrm{S,T}}$, as reported on the air-dried basis (see ISO 334, ISO 351 or ISO 19579), includes organic sulfur, $w_{\mathrm{S,o}}$, pyritic sulfur, $w_{\mathrm{S,p}}$, and sulfate sulfur, $w_{\mathrm{S,s}}$. The pyritic sulfur and the sulfate sulfur are determined and the organic sulfur is obtained by difference (see ISO 157). In order to convert the total sulfur content to a dry, mineral-matter-free basis, subtract the content of pyritic and sulfate sulfur as given in Formula (5):

$$w_{\mathrm{S,o.dmmf}} = (w_{\mathrm{S,T.ad}} - w_{\mathrm{S,p.ad}} - w_{\mathrm{S,s.ad}}) \times \frac{100}{100 - (w_{\mathrm{H2O.ad}} + w_{\mathrm{MM.ad}})} \tag{5}$$

5.7 Oxygen

Although oxygen is a significant component of coal and coke, there has been insufficient demand for its direct determination to justify continuation of an ISO standard.

The oxygen content is calculated by difference on an air-dried basis as given in Formula (6), which is taken from ISO 17247:

$$w_{\mathrm{O.ad}} = 100 - (w_{\mathrm{C.ad}} + w_{\mathrm{H.ad}} + w_{\mathrm{N.ad}} + w_{\mathrm{S,T.ad}} + w_{\mathrm{A.ad}} + w_{\mathrm{H2O.ad}}) \tag{6}$$

The calculated "oxygen by difference" includes the oxygen in the coal substance, in the carbonate minerals (as carbon dioxide) and in the water of hydration of the mineral matter.

The oxygen content on a dry, mineral-matter-free basis can be calculated as given in Formula (7):

$$w_{\mathrm{O.dmmf}} = 100 - (w_{\mathrm{C.dmmf}} + w_{\mathrm{H.dmmf}} + w_{\mathrm{N.dmmf}} + w_{\mathrm{S.T.dmmf}}) \tag{7}$$

It is necessary to exercise caution with the estimated result derived for "oxygen by difference" as it incorporates the summation of errors in the results of the other elements.

5.8 Chlorine

The chlorine content is reported on the air-dried basis (see ISO 587) and includes chlorine from the mineral matter and chlorine combined with the coal substance. It is, therefore, necessary to subtract the inorganic chlorine before calculating to the dry, mineral-matter-free basis as given in Formula (8):

$$w_{\mathrm{Cl.dmmf}} = (w_{\mathrm{Cl.ad}} - w_{\mathrm{Cl.inorg.ad}}) \times \frac{100}{100 - (w_{\mathrm{H20.ad}} + w_{\mathrm{MM.ad}})} \tag{8}$$

The content of inorganic chlorine may be calculated using a national factor, F_{Cl}, as given in Formula (9):

$$w_{\mathrm{Cl.inorg.ad}} = F_{\mathrm{Cl}} \times w_{\mathrm{Cl.ad}} \tag{9}$$

For higher rank coal, no chlorine combined with the coal matter has been found.[1] Therefore, a value $F_{\mathrm{Cl}} = 1$ may be used for these coals.

5.9 Volatile matter

The mineral matter associated with a sample also loses mass under the conditions of the volatile matter determination (see ISO 562), the magnitude of the loss being dependent on both the nature and the quantity of the minerals present.

Correction is, therefore, necessary prior to the calculation of the volatile matter to a dry, mineral-matter-free basis to take account of losses of sulfur, water of hydration, carbon dioxide and chlorine as given in Formula (10):

$$w_{\mathrm{V.dmmf}} = (w_{\mathrm{V.ad}} - w_{\mathrm{CO2.ad}} - 0.5 \times w_{\mathrm{S,p.ad}} - w_{\mathrm{h.ad}} - w_{\mathrm{Cl.ad}}) \times \frac{100}{100 - (w_{\mathrm{H2O.ad}} + w_{\mathrm{MM.ad}})} \tag{10}$$

The loss of mass from pyritic sulfur during devolatilization is approximately half of the sulfur bound in pyrite.

5.10 Net calorific value

The calculation of the net calorific value is dealt with in detail in ISO 1928, which, however, does not include calculation to a dry, mineral-matter-free basis as this basis is not of importance for net calorific values.

NOTE Net calorific values cannot be converted to any other basis by direct multiplying with the appropriate formulas in Table 1 as net calorific values includes a correction for the heat of vaporization related to the actual moisture content.

6 Calculations for coke analyses

Coke analyses may be expressed on the “air-dried”, “as-received”, “dry” and “dry, ash-free” bases, and these values (except for net calorific value) are calculated by the use of the appropriate formulae given in Table 1, after insertion of requisite numerical values for the symbols (for determination of moisture, see ISO 579 and ISO 687; for ash, see ISO 1171).

It is not proposed at present to recommend the calculation for the conversion of analytical results for coke to a dry, mineral-matter-free basis.

7 Table for calculation to different bases

Table 1 — Formulae for calculation of results to different bases

Basis of value given	**Basis of value wanted**				
	As analysed (air-dried) (ad)	**As received**[a] (ar)	**Dry** (d)	**Dry, ash free** (daf)	**Dry, mineral matter free** (dmmf)
As analysed (air-dried) (ad)	—	$\frac{100-w_{H2O.ar}}{100-w_{H2O.ad}}$	$\frac{100}{100-w_{H2O.ad}}$	$\frac{100}{100-(w_{H2O.ad}+w_{A.ad})}$	$\frac{100}{100-(w_{H2O.ad}+w_{MM.ad})}$
As received (ar)	$\frac{100-w_{H2O.ad}}{100-w_{H2O.ar}}$	—	$\frac{100}{100-w_{H2O.ar}}$	$\frac{100}{100-(w_{H2O.ar}+w_{A.ar})}$	$\frac{100}{100-(w_{H2O.ar}+w_{MM.ar})}$
Dry (d)	$\frac{100-w_{H2O.ad}}{100}$	$\frac{100-w_{H2O.ar}}{100}$	—	$\frac{100}{100-w_{A.d}}$	$\frac{100}{100-w_{MM.d}}$
Dry, ash-free (daf)	$\frac{100-(w_{H2O.ad}+w_{A.ad})}{100}$	$\frac{100-(w_{H2O.ar}+w_{A.ar})}{100}$	$\frac{100-w_{A.d}}{100}$	—	$\frac{100-w_{A.d}}{100-w_{MM.d}}$
Dry, mineral-matter-free (dmmf)	$\frac{100-(w_{H2O.ad}+w_{MM.ad})}{100}$	$\frac{100-(w_{H2O.ar}+w_{MM.ar})}{100}$	$\frac{100-w_{MM.d}}{100}$	$\frac{100-w_{MM.d}}{100-w_{A.d}}$	—

[a] Note that the formulae given for calculating results for the "as received" basis may be used to calculate them for any other moisture basis, for example moisture-holding capacity or bed moisture.

Annex A
(normative)

Mineral matter

In order to calculate analytical results for coal to a dry, mineral-matter-free basis, it is necessary to know the total amount of mineral matter present. This is normally determined on the air-dried test sample by the method specified in ISO 602. However, occasions can arise when it is expedient to estimate the amount of mineral matter from the ash by the application of equations that take account of the chemical changes occurring during the ashing process. The main changes are

a) liberation of water of hydration from silicates,

b) liberation of carbon dioxide from carbonates,

c) liberation of chlorine from chlorides,

d) oxidation of pyrites to iron(III) oxide with loss of sulfur,

e) fixation of sulfur by basic oxides.

Correction values for the last four chemical changes can be calculated with reasonable accuracy from readily determined constituents. However, the correction for the water of hydration in the silicate minerals, which is frequently greater than the sum of the remainder, is normally not very precise nor accurate because the determination is complex and is seldom carried out. Concentrations of the water of hydration ranging from 5 % to 20 % have been reported in various parts of the world, and it is clear that no single equation can find universal approval. The equation can be simple, as given in Formula (A.1):

$$w_{\mathrm{MM.ad}} = F_{\mathrm{MM}} \times w_{\mathrm{A.ad}} \qquad \text{(A.1)}$$

where F_{MM} is a national factor, depending on the actual type of coal. If no national factor is available, a value of F_{MM} equal to 1,1 may be used to calculate an estimated result.

The national equation may be more complex, i.e. including more variables than the ash, $w_{\mathrm{A.ad}}$.

If it is necessary to use a calculated (instead of a determined) value for mineral matter, then the equation used should be that recommended by the national standards organization in the country of origin of the sample. The equation should be quoted whenever it is used.

Bibliography

[1] Huggins F.E., & Huffman G.P. Chlorine in coal: an XAFS spectroscopic investigation. *Fuel*. 1995 April, **74** (Issue 4) pp. 556–569

[2] ISO 157, *Coal — Determination of forms of sulfur*

[3] ISO 334, *Solid mineral fuels — Determination of total sulfur — Eschka method*

[4] ISO 351, *Solid mineral fuels — Determination of total sulfur — High temperature combustion method*

[5] ISO 562, *Hard coal and coke — Determination of volatile matter*

[6] ISO 579, *Coke — Determination of total moisture*

[7] ISO 587, *Solid mineral fuels — Determination of chlorine using Eschka mixture*

[8] ISO 589, *Hard coal — Determination of total moisture*

[9] ISO 609, *Solid mineral fuels — Determination of carbon and hydrogen — High temperature combustion method*

[10] ISO 625, *Solid mineral fuels — Determination of carbon and hydrogen — Liebig method*

[11] ISO 687, *Solid mineral fuels — Coke — Determination of moisture in the general analysis test sample*

[12] ISO 1171, *Solid mineral fuels — Determination of ash*

[13] ISO 1928, *Solid mineral fuels — Determination of gross calorific value by the bomb calorimetric method and calculation of net calorific value*

[14] ISO 11722, *Solid mineral fuels — Hard coal — Determination of moisture in the general analysis test sample by drying in nitrogen*

[15] ISO 19579, *Solid mineral fuels — Determination of sulfur by IR spectrometry*

[16] ISO 29541, *Solid mineral fuels — Determination of total carbon, hydrogen and nitrogen content — Instrumental method*

ICS 73.040;75.160.10

Price based on 7 pages

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™