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Solid biofuels — Conversion of analytical results from one basis to another

Biocombustibles solides — Conversion de résultats analytiques d'une base en une autre base

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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 documents 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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 238, *Solid biofuels*.

This second edition cancels and replaces the first edition (ISO 16993:2015), of which it constitutes a minor revision.

Introduction

In the International Standards covering the analysis of solid biofuels, it is generally specified that the determination is intended to be carried out on the air-dried or in air-equilibrated general analysis test sample prepared according to ISO 14780. However, in making use of these analyses, it is necessary to express the results on dry basis and sometimes, also on some other basis. The bases in common use for solid biofuels are “air-dried” (sometimes stated as “as determined”), “as received” (sometimes stated “as sampled” or “as delivered”), “dry”, and “dry, ash free”.

Solid biofuels — Conversion of analytical results from one basis to another

1 Scope

This International Standard gives formulae which allow analytical data relating to solid biofuels to be expressed on the different bases in common use. Consideration is given to corrections that can be applied to certain determined values for solid biofuels prior to their calculation to other bases.

In Annex A, tools for integrity checks of analytical results are given. In Annex B, conversion factors for calculation into other units are given. Annex C is a guideline for the use of validation parameters as can be found in ISO/TC 238 analytical standards.

2 Normative 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 16948:2015, *Solid biofuels — Determination of total content of carbon, hydrogen and nitrogen*

ISO 16994, *Solid biofuels — Determination of total content of sulphur and chlorine*

ISO 18122, *Solid biofuels — Determination of ash content*

ISO 18125[1)], *Solid biofuels — Determination of calorific value*

ISO 18134-1, *Solid biofuels — Determination of moisture content — Oven dry method — Part 1: Total moisture — Reference method*

ISO 18134-2, *Solid biofuels — Determination of moisture content — Oven dry method — Part 2: Total moisture — Simplified method*

ISO 18134-3, *Solid biofuels — Determination of moisture content — Oven dry method — Part 3: Moisture in general analysis sample*

3 Symbols and abbreviated terms

The symbols employed in the subsequent clauses are as follows, with the suffixes “ad” (air-dried), “ar” (as received), “d” (dry), and “daf” (dry, ash free), where appropriate.

A	ash (percentage by mass) according to ISO 18122
C	total carbon content (percentage by mass) according to ISO 16948
Cl	total chlorine content (percentage by mass) according to ISO 16994
$q_{p,net}$	net calorific value at constant pressure (J/g) according to ISO 18125
H	total hydrogen content (percentage by mass) according to ISO 16948

1) To be published.

M moisture content (percentage by mass) according to ISO 18134-1, ISO 18134-2, and ISO 18134-3

N total nitrogen content (percentage by mass) according to ISO 16948

O total oxygen content (percentage by mass)

S total sulfur content (percentage by mass) according to ISO 16994

4 Principle

In order to convert an analytical result expressed as 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 into the formula in question.

5 Calculations for analyses of solid biofuels

5.1 General

Most analytical values on a particular basis can be converted to any other basis by multiplying it by a factor calculated from the appropriate formula given in Table 1, after insertion of the requisite numerical values into the formula in question. However, for some parameters, there is a direct involvement of the moisture content. In these cases, a correction (as specified in 5.2) of the air-dried result shall be carried out before calculation to dry basis or dry, ash-free basis. Also, if a result for these parameters expressed on a dry or a dry, ash-free basis is to be recalculated to a moist basis, the corrections stated in 5.2 shall be added back to the actual moist basis after applying the appropriate formula from Table 1.

5.2 Extra calculations for hydrogen, oxygen, and net calorific value

5.2.1 Hydrogen

The hydrogen content determined on the air-dried basis (H_{ad}, as analysed) includes both the hydrogen content of the combustible part of the solid biofuel, as well as the hydrogen present in the sample as moisture (total hydrogen content). Before calculation to any other basis, the determined hydrogen content, H_{ad}, shall be corrected of the moisture-bound hydrogen by calculation to dry basis, H_d, as shown in Formula (1):

$$H_d = \left(H_{ad} - \frac{M_{ad}}{8,937} \right) \times \frac{100}{\left(100 - M_{ad}\right)} \quad (1)$$

This hydrogen content, related to the combustible part of the solid biofuel, can be converted to any other basis using the formulae in Table 1.

With the constant factor 8,937, the hydrogen concentration in the water that is present in the sample is calculated. The factor is obtained from the molar formula of water (H_2O) and the atomic weight of hydrogen (1,008) and oxygen (15,999 4).

5.2.2 Oxygen

The oxygen content related to the combustible part of the solid biofuel can be calculated by difference on the dry basis using Formula (2):

$$O_d = 100 - C_d - H_d - N_d - S_d - Cl_d - A_d \quad (2)$$

If high precision is required, the values of S_d and Cl_d should be corrected for eventual remaining contents of sulfur and chlorine in the ash (A_d).

5.2.3 Net calorific value

The net calorific value at constant pressure on a moist basis ($q_{p,net,M}$) includes a correction for the heat of vaporization concerning the actual moisture content, M (M being e.g. M_{ad} or M_{ar}). Before conversion to any other basis, using the formulae in Table 1, this correction corresponding to 24,43 J/g per weight percent moisture (24,43 × M) shall be undone by adding 24,43 × M to the value of the net calorific value. After multiplying this sum with the appropriate formula from Table 1, the obtained value is to be corrected for the heat of vaporization concerning the new moisture content, M^*, by subtracting the value 24,43 × M^*. These corrections are illustrated in Formula (3) concerning the conversion of the net calorific value for a moisture content M ($q_{p,net,M}$ in J/g) to the net calorific value for a moisture content M^* (q_{p,net,M^*} in J/g), both at constant pressure.

$$q_{p,net,M^*} = \left[q_{p,net,M} + \left(24,43 \times M\right)\right] \times \frac{100 - M^*}{100 - M} - \left(24,43 \times M^*\right) \tag{3}$$

For the conversion of, e.g. the net calorific value on dry basis ($q_{p,net,d}$ in J/g) to the net calorific value on as received basis, ($q_{p,net,ar}$ in J/g) Formula (3) can be simplified into Formula (4):

$$q_{p,net,ar} = q_{p,net,d} \times \frac{100 - M_{ar}}{100} - 24,43 \times M_{ar} \tag{4}$$

as in this case, $M = 0$ and $M^* = M_{ar}$.

The net calorific value at a constant pressure for a dry sample ($q_{p,net,d}$) is derived from the corresponding gross calorific value at a constant volume according to ISO 18125.

5.3 General formulae for the conversion from one basis to another basis

After applying eventual corrections according to 5.2, analytical values on a particular basis can be converted to any other basis by multiplying it by a factor calculated from the appropriate formula given in Table 1, after insertion of the requisite numerical values into the formula in question.

Table 1 — Formulae for calculating conversion factors to convert analytical results from one basis to another

Given	Wanted			
	As analysed (air-dried) (ad)	As received[a] (ar)	Dry (d)	Dry, ash free (daf)
As analysed (air-dried, ad)		$\frac{100 - M_{ar}}{100 - M_{ad}}$	$\frac{100}{100 - M_{ad}}$	$\frac{100}{100 - \left(M_{ad} + A_{ad}\right)}$
As received (ar)	$\frac{100 - M_{ad}}{100 - M_{ar}}$		$\frac{100}{100 - M_{ar}}$	$\frac{100}{100 - \left(M_{ar} + A_{ar}\right)}$
Dry (d)	$\frac{100 - M_{ad}}{100}$	$\frac{100 - M_{ar}}{100}$		$\frac{100}{100 - A_d}$
Dry, ash free (daf)	$\frac{100 - \left(M_{ad} + A_{ad}\right)}{100}$	$\frac{100 - \left(M_{ar} + A_{ar}\right)}{100}$	$\frac{100 - A_d}{100}$	

[a] Note that the formulae given for calculating results to the "as received" basis can be used to calculate them to any other moisture bases.