BS ISO 24115:2012

BSI Standards Publication

Green coffee — Procedure for calibration of moisture meters — Routine method

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of ISO 24115:2012.

The UK participation in its preparation was entrusted to Technical Committee AW/15, Coffee.

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 66463 2

ICS 67.140.20

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 30 June 2012.

Amendments issued since publication

Date	Text affected

BS ISO 24115:2012

INTERNATIONAL STANDARD

ISO 24115

First edition
2012-06-01

Green coffee — Procedure for calibration of moisture meters — Routine method

Café vert — Mode opératoire d'étalonnage des humidimètres — Méthode de routine

Reference number
ISO 24115:2012(E)

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 24115 was prepared by Technical Committee ISO/TC 34, *Food products*, Subcommittee SC 15, *Coffee*.

Green coffee — Procedure for calibration of moisture meters — Routine method

1 Scope

This International Standard specifies a procedure for adjustment and subsequent calibration of moisture meters for green coffee beans with reference samples (RSs).

The RSs are green coffee beans of various moisture contents, determined by a standard method (ISO 6673).

NOTE This method of determining the loss in mass can be considered, by convention, as a method for determining the water content and can be used as such by agreement between the interested parties.

This International Standard is applicable to green coffee as beans.

2 Normative references

The following referenced documents are indispensable for the application 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 3509, *Coffee and coffee products — Vocabulary*

ISO 6673:2003, *Green coffee — Determination of loss in mass at 105 °C*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3509, ISO/IEC Guide 99, and the following apply.

3.1
reference sample
RS
sample of green coffee beans, sufficiently homogeneous and stable with reference to specified properties, which has been established to be fit for its intended use in measurement or in examination of nominal properties

NOTE See Annex A.

4 Principle

From green coffee beans, a set of samples with different moisture contents is prepared, to be taken as reference samples (RS). Their individual moisture content (or mass fraction loss) values are obtained by the respective determinations of loss in mass by applying ISO 6673.

These RSs with assigned moisture values are used for calibration of moisture meters.

5 Equipment and material

5.1 Green coffee as beans, in a quantity sufficient to prepare n reference samples, RSi, $i = 1 \dots n$ (the minimum is 5), with moisture mass fraction ranges between 8,5 % and 13,5 %, prepared according to A.1.

5.2 Thermometer, range between 0 °C to 120 °C, scale division 0,1 °C, provided the moisture meter does not display the sample temperature.

5.3 Moisture meter, equipped with all the accessories specified by the manufacturer. It shall include a channel for green coffee, which will be the subject of calibration.

5.4 Balance, capable of being read to the nearest 0,1 g.

5.5 Equipment necessary for determinations according to ISO 6673.

6 Procedure

6.1 Test conditions

The procedure shall be carried out at ambient temperature and at a relative humidity from 40 % to 70 %.

Prior to the test, allow conditioning of the green coffee bean RSs to ambient temperature.

6.2 Alignment of instrument deviation

6.2.1 Before adjustment, verify the equipment in accordance with the manufacturer's instructions.

NOTE The verification is necessary to ensure the electronic gauging.

6.2.2 For moisture meters with direct reading, select green coffee beans channel.

6.2.3 For each RSi, obtain the difference between the reference sample moisture mass fraction, $w_{\mathrm{RS}i}$, determined according to ISO 6673, and the moisture meter reading, $w_{\mathrm{r}i}$, where i is the reference sample number assigned. Record them as $\Delta w_i = w_{\mathrm{RS}i} - w_{\mathrm{r}i}$ in the column headed "Difference" of Table 1.

6.2.4 Calculate the average of the differences, $\overline{\Delta w}$, and adjust the moisture meter bias according to the manufacturer's operation manual.

Table 1 — Input values to obtain the bias for moisture meter adjustment

Reference sample RSi, i = 1 … n	**Moisture mass fraction of reference sample**[a] $w_{\mathrm{RS}i}$	**Equipment reading on sample** $w_{\mathrm{r}i}$	**Difference** $\Delta w_i = w_{\mathrm{RS}i} - w_{\mathrm{r}i}$
RS1			
RS2			
...			
RS(n − 1)			
RSn			
		$\overline{\Delta w}$	

[a] The moisture content (or mass fraction loss), $w_{\mathrm{RS}i}$, is obtained using ISO 6673.

6.3 Calibration of moisture meter

6.3.1 For calibration, use the moisture meter after adjustment (6.2).

6.3.2 Take the oven moisture values of the RSs, obtained according to A.2, and insert the figures into the appropriate w_{RSi} cells in Table 2.

6.3.3 Take a test portion from RS1 in accordance with the equipment manufacturer's instructions or the equipment capacity, and pour it into the moisture meter. Record the reading from the equipment in the cell matching the first row, RS1, and column, $w_{ri,1}$, of Table 2; this cell corresponds to $w_{r1,1}$.

Provided the equipment requires a defined test portion quantity, use the balance specified in 5.4.

6.3.4 Repeat the the procedure specified in 6.3.3 with the same test portion twice and record the readings in the subsequent cells which correspond to $w_{r1,2}$, and $w_{r1,3}$ for RS1.

At least three determinations shall be performed.

6.3.5 Calculate the arithmetic average of the RS1 readings, $w_{r1,1}$, $w_{r1,2}$, and $w_{r1,3}$, and record it in the corresponding cell of column $\overline{w_{ri,j}}$, $i = 1 \ldots n$; $j = 1,2,3$ of Table 2.

6.3.6 Calculate the experimental standard deviation, s_1, of $w_{r1,1}$, $w_{r1,2}$, and $w_{r1,3}$ and insert it into the corresponding cell of column s_i of Table 2.

6.3.7 Measure the temperature of the test portion RS1 and record it in the corresponding cell of column T_i of Table 2.

6.3.8 Repeat the procedure as specified in 6.3.3 to 6.3.7 with the other reference samples, RS2 to RSn and their test portions.

6.3.9 Determine a correction term, C_{ri}, to compensate for an estimated systematic effect of moisture for each w_{ri} moisture reading by applying Formula (1)

$$C_{ri} = w_{RSi} - \overline{w_{ri\,j}} \qquad i = 1 \ldots n \qquad j = 1,2,3 \tag{1}$$

NOTE For an example, see Table D.2.

Table 2 — Input values to obtain the calibration of moisture meter

Reference sample	Sample temperature °C	Equipment readings on RSs and corresponding mean				Standard deviation of reading	Reference sample moisture[a]	Moisture meter correction
RSi	T_i	$w_{ri,1}$	$w_{ri,2}$	$w_{ri,3}$	$\overline{w_{ri,j}}$	s_i	w_{RSi}	$C_{ri} = w_{RSi} - \overline{w_{ri\,j}}$
RS1								
RS2								
...								
RS(n – 1)								
RSn								

[a] The moisture content (or mass fraction loss), w_{RSi}, is obtained using ISO 6673; see A.2.

6.4 Temperature correction

6.4.1 Calculate the moisture reading correction term, C_T, due to bean temperature (if not automatically done by the instrument itself) based on equipment manufacturer instructions; otherwise follow steps 6.4.2 to 6.4.5.

NOTE Some manufacturers provide an automatic temperature correction programme with their instruments.

6.4.2 Determine the moisture content of the RSs with the moisture meter at a given temperature.

6.4.3 Increase the temperature of the samples by about 5 °C to 10 °C and determine the new values at the moisture meter.

6.4.4 For each RS, take the difference in moisture readings at test temperatures, and the difference of temperatures, and calculate the respective ratio

$$\xi_i = \frac{\Delta w_{\mathrm{r}i}}{\Delta T} \tag{2}$$

6.4.5 Calculate the arithmetic mean of the ratios, $\bar{\xi}$, to obtain the resulting moisture reading correction term C_T due to bean temperature.

$$C_T = \bar{\xi}\left(T_{\mathrm{ref}} - T_{\mathrm{s}}\right) \tag{3}$$

NOTE For an example, see Table D.4.

6.5 Calculation of uncertainty

This approach is based on that set out in ISO/IEC Guide 98-3:2008.[1]

When reporting the result of a measurement of a physical quantity, it is obligatory that some quantitative indication of the quality of the result be given so that those who use it can assess its reliability. Without such an indication, measurement results cannot be compared, either among themselves or with reference values given in a specification or standard.

It is therefore necessary that there is a readily implemented, easily understood, and generally accepted procedure for characterizing the quality of a result of a measurement, that is, for evaluating and expressing its uncertainty.1)

The components of moisture measurement uncertainty are:

a) $U_{\mathrm{RS}i}$: uncertainty of the (assigned) value of the reference sample;

b) $s_{\mathrm{r}i}/\sqrt{j}$: uncertainty type A given by the moisture meter readings obtained from the experimental standard deviation $s_{\mathrm{r}i}$ using reference material i, with $j = 3$ repetitions (see 6.3.6);

c) u_{Ba}: uncertainty type B due to moisture meter accuracy;

d) u_{Br}: uncertainty type B due to moisture meter resolution;

e) $u_{\mathrm{B}Ti}$: uncertainty type B due to the temperature (see 6.4 and D.4).

Calculate the expanded uncertainty of the moisture meter, $U_{\mathrm{m}i}$, for each moisture point i using Formula (4):

$$U_{\mathrm{m}i} = k\sqrt{\left(\frac{U_{\mathrm{RS}i}}{k}\right)^2 + \left(\frac{s_{\mathrm{r}i}}{\sqrt{3}}\right)^2 + u_{\mathrm{Ba}}^2 + u_{\mathrm{Br}}^2 + u_{\mathrm{B}Ti}^2} \tag{4}$$

where k is the coverage factor; generally $k = 2$ for a probability of 95 %, according to ISO/IEC Guide 98-3:2008.[1]

For each individual case, it is necessary to check every possible source of uncertainty.

1) In most cases, regressions are linear, however, it can prove necessary to apply another type, e.g. quadratic, regression.

6.6 Calibration curves for indirect reading equipment

If the equipment does not give a measurement result directly in moisture content, but as a dimensionless value, generate a calibration curve by comparing the equipment readings for each sample with the moisture of the RSs.

For a graphic calibration, plot the n values of the reading means, $\overline{w_{\mathrm{r}i,j}}$, on the abscissa against the n values of sample moisture content, $w_{\mathrm{RS}i}$ on the ordinate, with $i = 1 \ldots n$ for the samples and $j = 1, 2, 3$ for the replicate readings to obtain the calibration curve.

The calibration curve relates the equipment readings to moisture content (or mass fraction loss) of the reference samples.

For calculation, a linear regression is suitable in most cases.[1]

7 Expression of results

The moisture content of a sample, $w_{\mathrm{H_2O}}$, determined using a moisture meter which has been calibrated with the method described in this International Standard, shall be expressed as

$$w_{\mathrm{H_2O}} = \left(w_{\mathrm{r}} + C_{\mathrm{r}} + C_T \right) \pm U_{\mathrm{m}} \tag{5}$$

where

- w_{r} is the moisture content meter reading;
- C_{r} is the correction for the moisture meter reading;
- C_T is the correction for the moisture meter due to the temperature;
- U_{m} is the expanded uncertainty for the moisture mass fraction in the sample.

All values are given as percentage mass fractions.

NOTE D.6 gives an example of the final calculation.

Annex A
(normative)

Reference sample preparation and determination of moisture content as a mass fraction loss

A.1 Reference sample preparation

A.1.1 Decide the number, n ($n \geq 5$), of RSs to be used in the calibration process.

A.1.2 Select the starting material, green coffee beans of single species and homogeneous characteristics, with an initial moisture mass fraction between 14 % and 16 %.

NOTE 1 Depending on the measurement principle of the moisture meter to be calibrated and the precision required, it can prove necessary to perform individual calibrations for coffees of different bulk or intrinsic characteristics of the beans, like shape, size or any steaming pretreatment used.

NOTE 2 Some moisture meters allow different parallel installations of green coffee channels, adapted to the specific coffees to be analysed.

A.1.3 Obtain a total mass of green coffee quantity necessary to prepare n RSs, i.e. $n \times 600$ g, since, for each RS, 500 g is required for the moisture meter and an additional 100 g for the replicate moisture determinations according to ISO 6673.

The 500 g mass is recommended due to mass loss during the drying process, taking into consideration that most commercially available moisture meters accept up to 400 g.

A.1.4 Place one sample portion in the oven (5.5) at a temperature of 40 °C ± 2 °C. After drying, label it RS1.

A.1.5 Repeat the same procedure of A.1.4 with the other RSs, applying different drying times to obtain the RSi ($i = 1 \ldots n$) series with different moisture contents. Label the subsequent RSs as RS2, RS3 ... RSn until the desired moisture range is covered.

NOTE The validated mass fraction range with ISO 6673 is 8,5% to 13,5%.

Differences in moisture content, Δw, as percentage mass fractions, between two consecutive RSs should be in the range $0,7 \leq \Delta w \leq 1,3$.

A.1.6 Place each RS separately into an airtight container or a self-sealing double plastic bag and store them for 72 h to allow a homogeneous moisture distribution throughout each RS to be achieved.

A.2 Determination of oven moisture content (mass fraction loss)

A.2.1 When ready, take from each of RS1, RS2 ... RSn at least three test portions to perform the procedure in ISO 6673:2003, Clause 7. Mark each test portion as $O_{1,1}$, $O_{1,2}$, $O_{1,3}$, $O_{2,1}$, $O_{2,2}$, $O_{2,3}$ ... $O_{n,1}$, $O_{n,2}$, $O_{n,3}$, where O denotes “oven”.

A.2.2 Determine the moisture content (or mass fraction loss) of RS1 in accordance with ISO 6673. Use Table A.1 to record the values $w_{O_{1,1}}$, $w_{O_{1,2}}$, and $w_{O_{1,3}}$ in the appropriate mass fraction columns.

A.2.3 Calculate the arithmetic mean of the three values for RS1 obtained in A.2.2, and record it in Table A.1, column $\overline{w_{\text{RS}i}}$.

A.2.4 Calculate the standard deviation, s_{O_1}, of $w_{\text{O}_{1,1}}$, $w_{\text{O}_{1,2}}$, and $w_{\text{O}_{1,3}}$ and record it in Table A.1, column $s_{\text{RS}i}$.

A.2.5 Calculate the standard uncertainty, u_1, of $w_{\text{O}_{1,1}}$, $w_{\text{O}_{1,2}}$, and $w_{\text{O}_{1,3}}$ as $u_1 = s_{\text{O}_1} / \sqrt{3}$ and record it in Table A.1, column u_i.

A.2.6 Calculate the expanded uncertainty: U_{RS1} as ku_1 and record it in Table A.1, column $U_{\text{RS}i}$.

A.2.7 Repeat the procedure specified in A.2.2 to A.2.6 with RS2 to RSn.

NOTE Table B.1 gives an example of the use of Table A.1.

A.2.8 Pack the remaining material from each RS in an airtight container or a self-sealing double plastic bag. Label them as specified in A.3.

A.2.9 If there is a delay between oven moisture determination and usage of the RSs for moisture meter calibration, a re-checking of oven moisture may become necessary. The expiry time depends on storage conditions.

A.3 Reference sample labelling

The labels for the reference samples shall clearly indicate:

a) the coffee species (e.g. *Coffea arabica* or *C. canephora*);

b) whether decaffeinated or non-decaffeinated;

c) the moisture content of each reference sample and the standard method used to determine it;

d) the uncertainty of reference sample moisture content;

e) the date of reference sample preparation;

f) the expiry time of the reference sample.

Table A.1 — Input values in order to calculate moisture by oven ISO 6673

Reference sample, RSi	Test portion for oven moisture	Dish and lid No.	Mass of dish	Mass of sample	Mass of lid	Total mass		$\frac{(m_1 - m_2)}{m_0} \times 100$	Mean moisture content ISO 6673	Standard deviation	Uncer-tainty	Expanded uncer-tainty
			m_D	m_0	m_L	Initial,[a] m_1	Final,[b] m_2		$\overline{w_{RSi}}$	s_{RSi}	u_i	U_{RSi}
			g	g	g	g	g	% mass fraction	% mass fraction	% mass fraction	% mass fraction	% mass fraction
RS1	$O_{1,1}$											
	$O_{1,2}$											
	$O_{1,3}$											
RS2	$O_{2,1}$											
	$O_{2,2}$											
	$O_{2,3}$											
RSi	$O_{i,1}$											
	$O_{i,2}$											
	$O_{i,3}$											
RSn	$O_{n,1}$											
	$O_{n,2}$											
	$O_{n,3}$											

[a] The total mass of dish, lid and sample prior to the oven procedure is $m_1 = m_D + m_0 + m_L$.

[b] The total mass of dish, lid and sample after the oven procedure is m_2.

Annex B
(informative)

Example for moisture determination of samples to serve as reference

B.1 Example for reference sample moisture data processing

The following table gives real case data for moisture determination of a set of samples to be considered as reference samples (RS) as described in Annex A, and the resulting parameters. The data were obtained as loss in mass according to ISO 6673, at a lab participating in the test.

Table B.1 — Experimental data of moisture determination according to ISO 6673 and calculation of results

Reference sample, RSi	Test portion	Dish and lid No.	Mass of dish m_D g	Mass of sample m_0 g	Mass of lid m_L g	Total mass Initial, m_1 g	Total mass Final, m_2 g	Mass fraction loss % mass fraction	Mean moisture content ISO 6673 $\overline{w_{RSi}}$ % mass fraction	Standard deviation s_{RSi} % mass fraction	Uncertainty u_i % mass fraction	Expanded uncertainty U_{RSi} % mass fraction
RS1	$O_{1,1}$	31	28,943 6	10,775 0	43,568 3	83,286 4	82,333 6	8,84	8,88	0,04	0,02	0,04
	$O_{1,2}$	33	31,496 5	10,356 3	33,821 6	75,674 7	74,751 1	8,92				
	$O_{1,3}$	4	32,079 5	10,045 8	34,790 1	76,915 9	76,022 7	8,89				
RS2	O_{21}	20	31,241 7	10,740 5	37,554 4	79,536 3	78,498 6	9,66	9,63	0,03	0,02	0,03
	$O_{2,2}$	6	42,796 3	10,061 2	39,421 3	92,278 9	91,312 8	9,60				
	$O_{2,3}$	10	41,327 5	10,502 5	37,602 5	89,433 0	88,422 1	9,63				
RS3	$O_{3,1}$	9	33,626 0	10,217 2	42,565 1	86,408 1	85,285 9	10,98	10,99	0,02	0,01	0,03
	$O_{3,2}$	30	43,685 4	10,312 4	44,688 2	98,685 8	97,549 4	11,02				
	$O_{3,3}$	14	42,502 4	10,432 7	43,325 8	96,261 1	95,115 9	10,98				
RS4	$O_{4,1}$	25	43,551 3	10,304 2	34,339 1	88,195 0	86,979 8	11,79	11,76	0,03	0,02	0,04
	$O_{4,2}$	2	32,024 3	10,491 9	32,747 2	75,263 0	74,032 5	11,73				
	$O_{4,3}$	21	32,548 5	10,672 7	36,493 2	79,713 8	78,459 4	11,75				
RS5	$O_{5,1}$	3	42,147 9	10,473 8	43,800 9	96,423 1	95,110 2	12,54	12,49	0,04	0,02	0,04
	$O_{5,2}$	12	33,253 4	10,359 0	34,550 2	78,162 3	76,871 7	12,46				
	$O_{5,3}$	5	32,548 7	10,644 9	35,083 5	78,276 9	76,947 9	12,48				
RS6	$O_{6,1}$	7	31,476 5	10,858 3	37,128 1	79,461 9	77,981 4	13,63	13,66	0,02	0,01	0,03
	$O_{6,2}$	1	41,211 2	10,790 6	37,195 1	89,197 0	87,720 5	13,68				
	$O_{6,3}$	11	31,962 5	10,091 6	42,584 3	84,638 4	83,259 4	13,66				

Annex C
(informative)

Results of interlaboratory tests

C.1 Interlaboratory tests, moisture determination with ISO 6673

The calibration method has been evaluated in several interlaboratory tests.

For the moisture determination procedure, the first ring test was run in parallel to the work for the publication of ISO 6673:2003. The ring test validation originally covered the mass fraction range 8,5 % to 11,4 %; Table C.1 shows the results.

Table C.1 — Results of the interlaboratory test in accordance with ISO 6673

Parameter	Sample				
	A	B	C	D	E
No. of laboratories retained after eliminating outliers	13	13	13	13	13
Mean, % mass fraction	8,50	9,11	9,14	11,10	11,40
Standard deviation of repeatability, s_r, % mass fraction	0,09	0,04	0,06	0,09	0,12
Coefficient of variation of repeatability, %	1,1	0,4	0,7	0,8	1,1
Repeatability limit, $r = 2{,}8 \times s_r$, % mass fraction	0,25	0,11	0,17	0,25	0,34
Standard deviation of reproducibility, s_R, % mass fraction	0,21	0,42	0,33	0,19	0,22
Coefficient of variation of reproducibility, %	2,5	4,6	3,6	1,7	1,9
Reproducibility limit, $R = 2{,}8 \times s_R$, % mass fraction	0,59	1,19	0,93	0,54	0,62

For the purpose of this International Standard, an expansion of the ISO 6673 validation range for calibration of moisture meters was necessary. This was done in the context of the work on this International Standard.

Samples with the various moistures required for the test were prepared from one starting material, according to A.1, and distributed to the nine laboratories willing to participate in the calibration ring test.

The international ring test was performed in 2002. The results and precision data on the moisture determination according to A.2 are given in Table C.2, expanding the validated range to 13,5 %.

Table C.2 — Interlaboratory test 2002: moisture determination by using ISO 6673 (moisture mass fraction range 9,37 % to 13,52 %)

Parameter	Sample				
	O_1	O_2	O_3	O_4	O_5
No. of laboratories retained after eliminating outliers	7	7	7	7	7
Mean, % mass fraction	13,52	12,53	11,42	10,52	9,37
Standard deviation of repeatability, s_r, % mass fraction	0,11	0,08	0,06	0,10	0,14
Coefficient of variation of repeatability, %	0,8	0,6	0,5	1,0	1,5
Repeatability limit, $r = 2{,}8 \times s_r$, % mass fraction	0,31	0,22	0,17	0,28	0,39
Standard deviation of reproducibility, s_R, % mass fraction	0,12	0,13	0,13	0,14	0,17
Coefficient of variation of reproducibility, %	0,9	1,1	1,1	1,3	1,8
Reproducibility limit, $R = 2{,}8 \times s_R$, % mass fraction	0,34	0,36	0,36	0,39	0,48

Annex D
(informative)

Examples for separate steps of the procedure

D.1 General

Tables D.1 to D.6 give examples for the specific use of this International Standard step by step, with real case data, obtained during the ring tests and from manufacturers' calibration certificates.

The tables are cross-referenced to the respective steps of the procedure.

Data are used from a moisture meter (A) of the test series, which has a resolution of 0,1 % and an accuracy of 0,3 % stated by the manufacturer, which is to be calibrated with reference materials described in Annex B.

The tabulated data show the procedural steps.

D.2 Adjustment of moisture meter according to 6.2

See Table D.1.

For this moisture meter, the bias was determined as –1,4 %.

D.3 Calibration of moisture meter according to 6.3

See Table D.2.

D.4 Correction table constructed over the range of a calibration

The moisture correction terms can be displayed in a correction table.

Table D.3 is constructed from a real case example, taken from a moisture meter (A) in the test, run at 21,8 °C, calibration range 9 % to 13,5 %.

D.5 Calculation of temperature correction according to 6.4, procedure following manufacturer's manual

See Table D.4.

The sensitivity coefficient of temperature is determined to be 0,03 % mass fraction/°C.

The temperature correction at sample temperature, T_s, is to be calculated as

$$C_T = 0{,}03 \times (21{,}8\ °C - T_s)$$

See Table D.2.

D.6 Calculation of expanded uncertainty

The calculation of uncertainty components for each of the reference samples is summarized in Table D.5.

The resulting expanded uncertainty given by Formula (4) is listed in Table D.6 for each of the samples.

D.7 Expression of results

With the previously mentioned moisture data, a sample temperature, T_s, of 25 °C, and a meter reading of 9,6 %, the corrected moisture value of the sample is calculated as follows:

$$w_{H_2O} = (w_r + C_r + C_T) \pm U_m$$

$$w_{H_2O} = (9,6 + 0,1 + 0,1) \pm 0,4$$

resulting in the mass fraction

$$w_{H_2O} = (9,8 \pm 0,4)\ \%$$

Table D.1 — Determination of the bias of the moisture meter for adjustment

Reference sample RSi	Moisture mass fraction in RSs w_{RSi}	Equipment reading on RSs w_{ri}	Difference $\Delta w_i = w_{RSi} - w_{ri}$
RS1	8,88	10,1	-1,2
RS2	9,63	10,9	-1,3
RS3	10,99	12,4	-1,4
RS4	11,76	13,4	-1,6
RS5	12,49	13,9	-1,4
RS6	13,66	15,0	-1,3
		$\overline{\Delta w}$	–1,4

Table D.2 — Input values to obtain the calibration of moisture meter

Reference sample	Sample temperature °C	Equipment readings on RSs and corresponding mean				Standard deviation of readings	Oven moisture of reference samples	Moisture meter correction
RSi	T_s	w_{r1}	w_{r2}	w_{r3}	$\overline{w_{ri}}$	s_i	w_{RSi}	C_{ri}
RS1	21,7	8,7	8,7	8,6	8,67	0,06	8,88	0,21
RS2	21,9	9,5	9,6	9,6	9,57	0,06	9,63	0,06
RS3	21,8	11	10,9	11,1	11,00	0,10	10,99	−0,01
RS4	21,9	11,7	11,9	11,9	11,83	0,12	11,76	−0,07
RS5	21,6	12,6	12,7	12,4	12,57	0,15	12,49	−0,08
RS6	21,7	13,7	13,8	13,6	13,70	0,10	13,66	−0,04

Table D.3 — Table of corrections for moisture meter

Reading w_r	Correction C_r	Reading w_r	Correction C_r	Reading w_r	Correction C_r
9,0	0,2	10,5	0,0	12,1	−0,1
9,1	0,1	10,6	0,0	12,2	−0,1
9,2	0,1	10,7	0,0	12,3	−0,1
9,3	0,1	10,8	0,0	12,4	−0,1
9,4	0,1	10,9	0,0	12,5	−0,1
9,5	0,1	11	0,0	12,6	−0,1
9,6	0,1	11,1	0,0	12,7	−0,1
9,7	0,1	11,2	0,0	12,8	−0,1
9,8	0,1	11,3	0,0	12,9	−0,1
9,9	0,1	11,4	0,0	13	−0,1
10	0,0	11,5	−0,1	13,1	−0,1
10,1	0,0	11,6	−0,1	13,2	−0,1
10,2	0,0	11,7	−0,1	13,3	−0,1
10,3	0,0	11,8	−0,1	13,4	−0,1
10,4	0,0	11,9	−0,1	13,5	0,0

Table D.4 — Determination of sensitivity coefficient of temperature

Temperature °C T_1	w_{rT_1}	Temperature °C T_2	w_{rT_2}	$\frac{\Delta w_r}{\Delta T}$
21,7	8,6	27,7	8,8	0,03
21,9	9,6	27,6	9,7	0,02
21,8	11,1	27,8	11,3	0,03
21,9	11,9	27,5	12,1	0,04
21,6	12,4	27,4	12,6	0,03
21,7	13,6	27,3	13,8	0,04
			$\bar{\xi} = \overline{\left(\frac{\Delta w_r}{\Delta T}\right)}$	0,03

Table D.5 — Calculation of uncertainty components

Concept	Type	Uncertainty components	Values	Results
Uncertainty for the reference sample (RS_i)	B	$u_{RSi} = \frac{U_{RSi}}{k}$ $k = 2$	$U_{RS1} = 0,04$	0,020
			$U_{RS2} = 0,03$	0,015
			$U_{RS3} = 0,03$	0,015
			$U_{RS4} = 0,04$	0,020
			$U_{RS5} = 0,04$	0,020
			$U_{RS6} = 0,03$	0,015
Standard uncertainty for the moisture meter reading	A	$\frac{s_{ri}}{\sqrt{j}}$ $j = 3$	$s_{r1} = 0,15$	0,035
			$s_{r2} = 0,15$	0,035
			$s_{r3} = 0,15$	0,058
			$s_{r4} = 0,15$	0,069
			$s_{r5} = 0,15$	0,087
			$s_{r6} = 0,15$	0,058
Uncertainty for the moisture meter accuracy, a	B	$u_{Be} = \frac{a_+ - a_-}{\sqrt{12}}$	$a = \pm 0,3$[a]	0,173
Uncertainty for the moisture meter resolution, r_{mm}	B	$u_{Br_{mm}} = \frac{r_{mm}}{4\sqrt{3}}$	$r_{mm} = 0,1$[a]	0,014
Uncertainty for the moisture meter temperature	B	$u_{BTi} = \frac{U_T}{k}\bar{\xi}$	$U_T = 0,5$[b] $k = 2$ $\bar{\xi} = 0,03$	0,008

a According to the manufacturer's documentation.

b Value from the thermometer calibration certificate of the moisture meter.

Table D.6 — Expanded uncertainty

Expanded uncertainty % mass fraction	
U_{m1}	0,36
U_{m2}	0,36
U_{m3}	0,37
U_{m4}	0,38
U_{m5}	0,39
U_{m6}	0,37

Bibliography

[1] ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM)*

ICS 67.140.20

Price based on 16 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.

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 Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™