INTERNATIONAL
RECOMMENDATION

OIML R 111-1:2004
Amendment 2025

Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3

Amendment 2025 to R 111-1:2004

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

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Weights of classes E_1, E_2, F_1, F_2, M_1, M_{1-2}, M_2, M_{2-3} and M_3

Subclause 1.3 - Minimum accuracy class of weights

Subclause 1.3.1 of the published version of OIML R 111-1:2004 (page 4) currently reads:

1.3.1 The OIML weight classes are defined as follows:

Class E_1: Weights intended to ensure traceability between national mass standards (with values derived from the International Prototype of the kilogram) and weights of class E_2 and lower.

Subclause 1.3.1 should be corrected to read:

1.3.1 The OIML weight classes are defined as follows:

Class E_1: Weights intended to ensure traceability between national mass standards (with values derived from **internationally recognised realisations of the definition of the kilogram in the SI**) and weights of class E_2 and lower.

Subclause 15.1 – Type approval

Subclause 15.1.2 of the published version of OIML R 111-1:2004 (page 23) currently reads:

15.1.2 An approved model or type shall not be modified without special authorization once it has received type approval (see OIML B 3 OIML Certificate System for Measuring Instruments).

Subclause 15.1.2 should be corrected to read:

15.1.2 An approved model or type shall not be modified without special authorization once it has received type approval (see OIML B 18 *Framework for the OIML Certification System (OIML-CS)*[42]).

Annex B - Test procedures for weights

Subclause B.1.2 of the published version of OIML R 111-1:2004 (page 28) currently reads:

B.1.2 The term “conventional mass” is used everywhere, except in the density section where the term “real mass” is used (see 2.6).

Subclause B.1.2 should be corrected to read:

B.1.2 The term “conventional mass” is used everywhere, except in the density section where the term “real mass” is used (**see 2.7 and 2.8**).

Subclause B.4.3.1, Table B2 of the published version of OIML R 111-1:2004 (page 29) currently reads:

ΔT*	Nominal Value	Class E_1	Class E_2	Class F_1	Class F_2
± 20 °C	1 000, 2 000, 5 000 kg	-	-	79	**5**
	100, 200, 500 kg	-	70	33	4
	10, 20, 50 kg	45	27	12	3
	1, 2, 5 kg	18	12	6	2
	100, 200, 500 g	8	5	3	1
	10, 20, 50 g	2	2	1	1
	< 10 g	1			0.5
± 5 °C	1 000, 2 000, 5 000 kg	-	-	1	1
	100, 200, 500 kg	-	40	2	1
	10, 20, 50 kg	36	18	4	1
	1, 2, 5 kg	15	8	3	1
	100, 200, 500 g	6	4	2	0.5
	10, 20, 50 g	2	1	1	0.5
	< 10 g	0.5			
± 2 °C	1 000, 2 000, 5 000 kg	-	-	1	0.5
	100, 200, 500 kg	-	16	1	0.5
	10, 20, 50 kg	27	10	1	0.5
	1, 2, 5 kg	12	5	1	0.5
	100, 200, 500 g	5	3	1	0.5
	< 100 g	2	1		0.5
± 0.5 °C	1 000, 2 000, 5 000 kg	-	-	-	-
	100, 200, 500 kg	-	1	0.5	0.5
	10, 20, 50 kg	11	1	0.5	0.5
	1, 2, 5 kg	7	1	0.5	0.5
	100, 200, 500 g	3	1	0.5	0.5
	< 100 g	1	0.5		

Subclause B.4.3.1, Table B2 should be corrected to read:

ΔT*	Nominal Value	Class E_1	Class E_2	Class F_1	Class F_2
± 20 °C	1 000, 2 000, 5 000 kg	-	**93****	79	**7**
	100, 200, 500 kg	-	70	33	4
	10, 20, 50 kg	45	27	12	3
	1, 2, 5 kg	18	12	6	2
	100, 200, 500 g	8	5	3	1
	10, 20, 50 g	2	2	1	1
	< 10 g	1			0.5
± 5 °C	1 000, 2 000, 5 000 kg	-	**51****	1	1
	100, 200, 500 kg	-	40	2	1
	10, 20, 50 kg	36	18	4	1
	1, 2, 5 kg	15	8	3	1
	100, 200, 500 g	6	4	2	0.5
	10, 20, 50 g	2	1	1	0.5
	< 10 g	0.5			
± 2 °C	1 000, 2 000, 5 000 kg	-	**16****	1	0.5
	100, 200, 500 kg	-	16	1	0.5
	10, 20, 50 kg	27	10	1	0.5
	1, 2, 5 kg	12	5	1	0.5
	100, 200, 500 g	5	3	1	0.5
	< 100 g	2	1		0.5
± 0.5 °C	1 000, 2 000, 5 000 kg	-	-	-	-
	100, 200, 500 kg	-	1	0.5	0.5
	10, 20, 50 kg	11	1	0.5	0.5
	1, 2, 5 kg	7	1	0.5	0.5
	100, 200, 500 g	3	1	0.5	0.5
	< 100 g	1	0.5		

** only for weights with a nominal value of 1 000 kg

Subclause B.6.2.3.h, equation B.6.2-2 of the published version of OIML R 111-1:2004 (page 34) currently reads:

- $f(B_E) = 5.4\ B_E$ for class M weights

Subclause B.6.2.3.h, equation B.6.2-2 should be corrected to read:

- $f(B_E) = 5.4\ B_E$ for class M cylindrical weights made of grey cast iron, and
- $f(B_E) = 2.5\ B_E$ for class M rectangular weights.

Subclause B.6.2.3.h, equation B.6.2-3 of the published version of OIML R 111-1:2004 (page 34) currently reads:

- $f(B_E) = \frac{\chi}{1+0.23\chi}\ B_E$ for class E and F weights

Subclause B.6.2.3.h, equation B.6.2-2 should be corrected to read:

- $f(B_E) = \frac{\chi}{1+0.23\chi}\ B_E$ for class E, F and M cylindrical weights made of material with low magnetic susceptibility ($\chi < 1$)

Subclause B.7.4, equation B.7.4-8 of the published version of OIML R 111-1:2004 (page 47) currently reads:

$$\left(\frac{u(\rho_t)}{\rho_t}\right)^2 = \left(c(\rho_a)\frac{u(\rho_a)}{\rho_a}\right)^2 + \left(c(\rho_{al})\frac{u(\rho_{al})}{\rho_{al}}\right)^2 + \left(\frac{u(\rho_l)}{\rho_l}\right)^2 + \left(c(\rho_{ra})\frac{u(\rho_{ra})}{\rho_{ra}}\right)^2 + \left(c(\rho_{rl})\frac{u(\rho_{rl})}{\rho_{rl}}\right)^2 +$$

$$c^2(m_r)\left[\left(2\frac{u(m_r)}{m_r}\right)^2 + \left(\frac{u(\Delta m_{wa})}{m_{ra}}\right)^2 + \left(\frac{u(\Delta m_{wl})}{m_{rl}}\right) + \left(\frac{u(m_{cap})}{m_{rl}}\right)^2\right]$$

Subclause B.7.4, equation B.7.4-8 should be corrected to read

$$\left(\frac{u(\rho_t)}{\rho_t}\right)^2 = \left(c(\rho_a)\frac{u(\rho_a)}{\rho_a}\right)^2 + \left(c(\rho_{al})\frac{u(\rho_{al})}{\rho_{al}}\right)^2 + \left(\frac{u(\rho_l)}{\rho_l}\right)^2 + \left(c(\rho_{ra})\frac{u(\rho_{ra})}{\rho_{ra}}\right)^2 + \left(c(\rho_{rl})\frac{u(\rho_{rl})}{\rho_{rl}}\right)^2 +$$

$$c^2(m_r)\left[\left(2\frac{u(m_r)}{m_r}\right)^2 + \left(\frac{u(\Delta m_{wa})}{m_{ra}}\right)^2 + \left(\frac{u(\Delta m_{wl})}{m_{rl}}\right)^2 + \left(\frac{u(m_{cap})}{m_{rl}}\right)^2\right]$$

Subclause B.7.4, equation B.7.4-17 of the published version of OIML R 111-1:2004 (page 47) currently reads:

$$\left(\frac{u(\rho_t)}{\rho_t}\right)^2 = \left(c(\rho_a)\frac{u(\rho_a)}{\rho_a}\right)^2 + \left(\frac{u(\rho_l)}{\rho_l}\right)^2 +$$

$$c^2(m_r)\left[\left(2\frac{u(m_r)}{m_r}\right)^2 + \left(\frac{u(\Delta m_{wa})}{m_{ra}}\right)^2 + \left(\frac{u(\Delta m_{wl})}{m_{rl}}\right) + \left(\frac{u(m_{cap})}{m_{rl}}\right)^2\right] + u_c^2$$

Subclause B.7.4, equation B.7.4-17 should be corrected to read

$$\left(\frac{u(\rho_t)}{\rho_t}\right)^2 = \left(c(\rho_a)\frac{u(\rho_a)}{\rho_a}\right)^2 + \left(\frac{u(\rho_l)}{\rho_l}\right)^2 +$$

$$c^2(m_r)\left[\left(2\frac{u(m_r)}{m_r}\right)^2 + \left(\frac{u(\Delta m_{wa})}{m_{ra}}\right)^2 + \left(\frac{u(\Delta m_{wl})}{m_{rl}}\right)^2 + \left(\frac{u(m_{cap})}{m_{rl}}\right)^2 + u_c^2\right]$$

Subclause B.7.8, equation B.7.8-4 of the published version of OIML R 111-1:2004 (page 57) currently reads:

$$V_D = \frac{1}{12} l_3 \left(l_1^2 + l_1 l_2 + l_2^2\right)$$

Subclause B.7.8, equation B.7.8-4 should be corrected to read

$$V_D = \frac{\pi}{12} l_3 \left(l_1^2 + l_1 l_2 + l_2^2\right)$$

Subclause B.7.9.4.2 of the published version of OIML R 111-1:2004 (page 58) currently reads:

B.7.9.4.2 Density of a composite weight

The same equation can also be used to determine the resulting density if two different constituents make up a weight or if two weights of different densities are used as a reference. The preferred metals for adjusting weights are tungsten (18 800 kg m^{-3} ± 200 kg m^{-3}), lead (11 300 kg m^{-3} ± 150 kg m^{-3}), molybdenum (10 000 kg m^{-3} ± 150 kg m^{-3}) and tin (7 kg m^{-3} ± 100 kg m^{-3}).

Subclause B.7.9.4.2 should be corrected to read:

B.7.9.4.2 Density of a composite weight

The same equation can also be used to determine the resulting density if two different constituents make up a weight or if two weights of different densities are used as a reference. The preferred metals for adjusting weights are tungsten (18 800 kg m^{-3} ± 200 kg m^{-3}), lead (11 300 kg m^{-3} ± 150 kg m^{-3}), molybdenum (10 000 kg m^{-3} ± 150 kg m^{-3}) and tin (**7 300** kg m^{-3} ± 100 kg m^{-3}).

Annex C - Calibration of a weight or weight set

Subclause C.4 of the published version of OIML R 111-1:2004 (page 63) currently reads:

Note: Other procedures and weighing cycles may be used. If in particular, weighing cycles are used that are not independent from each other, such as A1 B2 A2, A2 B2 A3, ..., the uncertainty has to be evaluated by considering covariance terms and the formula given in C.6.1 has to be modified correspondingly [33].

Subclause C.4 should be corrected to read:

Note: Other procedures and weighing cycles may be used. If in particular, weighing cycles are used that are not independent from each other, such as A1 B**1** A2, A2 B2 A3, ..., the uncertainty has to be evaluated by considering covariance terms and the formula given in C.6.1 has to be modified correspondingly [33].

Subclause C.6.1.3 of the published version of OIML R 111-1:2004 (page 66) currently reads:

If only a few measurements are made, the estimate of $s(\Delta m_c)$ can be unreliable. A pooled estimate, obtained from earlier measurements made under similar conditions, should be used (see D.1.2). If this is not possible, *n* should not be less than 5.

Subclause C.6.1.3 should be corrected to read:

If only a few measurements are made, the estimate of $s(\Delta m_c)$ can be unreliable. A pooled estimate, obtained from earlier measurements made under similar conditions, should be used (see D.**2**). If this is not possible, *n* should not be less than 5.

Annex E – The CIPM formula

Subclause E.1 of the published version of OIML R 111-1:2004 (page74) currently reads:

This formula became known as the CIPM-81 equation. Since its publication in 1981, there have been several changes made to the recommended value of the constants used. The formula is now referred to as the "1981/91 equation for the determination of the density of moist air" or just the "1981/91 equation" after the 1991 Consultative Committee for Mass (CCM) meeting amended several of the constants used in the formula.

Subclause E.1 should be corrected to read:

This formula became known as the CIPM-81 equation. Since its publication in 1981, there have been several changes made to the recommended value of the constants used. The formula is now referred to as the "1981/91 equation for the determination of the density of moist air" or just the "1981/91 equation" after the 1991 Consultative Committee for Mass (CCM) meeting amended several of the constants used in the formula.

The formula was corrected in 2007 and is now know as CIPM-2007 [41]

The CODATA value for *R* was updated in 2018. The currently accepted value is:

8.314 462 618 … J K^{-1} mol^{-1} (the value is considered exact).

Subclause E.2.1 of the published version of OIML R 111-1:2004 (page 63) currently reads:

E.2.1 Molar mass of dry air, M_a

The molar mass of dry air, M_a, can be calculated, using x_{CO_2} as the mole fraction of carbon dioxide, as follows:

$$M_a = [28.9635 + 12.011\ (x_{CO_2} - 0.0004)] \times 10^{-3}\ \text{kg mol}^{-1} \qquad \text{(E.2.1-1)}$$

Table E.1 Recommended value for M_a/R with $x_{CO_2} = 0.0004$

Constant	1991 recommended value	Units
M_a/R	3.483 49	10^{-3} kg KJ^{-1}

Subclause E.2.1 should be corrected to read:

E.2.1 Molar mass of dry air, M_a

The molar mass of dry air, M_a, can be calculated, using x_{CO_2} as the mole fraction of carbon dioxide, as follows:

$$M_a = [28.965\ 46 + 12.011\ (x_{CO_2} - 0.0004)] \times 10^{-3}\ \text{kg mol}^{-1} \qquad \text{(E.2.1-1)}$$

Table E.1 Recommended value for M_a/R with $x_{CO_2} = 0.0004$

Constant	2007 recommended value	Units
M_a/R	3.483 51	10^{-3} kg K J^{-1}

The following references should be added (page 78):

[41] A Picard, R S Davis, M Glaser and K Fujii, "Revised formula for the density of moist air (CIPM-2007), *Metrologia*, **45** (2008) 149–155

[42] OIML B 18 *Framework for the OIML Certification System (OIML-CS)* (2018)