BRITISH STANDARD

BS EN 60318-6:2008

Electroacoustics — Simulators of human head and ear —

Part 6: Mechanical coupler for the measurement of bone vibrators

ICS 17.140.50

British Standards

National foreword

This British Standard is the UK implementation of EN 60318-6:2008. It is identical to IEC 60318-6:2007. It supersedes BS 4009:1991 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electroacoustics.

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

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(IEC 60318-6:2007)

Electroacoustique -
Simulateurs de tête et d'oreille humaines -
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destiné à la mesure des ossivibrateurs
(CEI 60318-6:2007)

Akustik -
Simulatoren des menschlichen
Kopfes und Ohres -
Teil 6: Mechanischer Kuppler
für Messungen an Knochenleitungshörern
(IEC 60318-6:2007)

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Foreword

The text of document 29/615/CDV, future edition 1 of IEC 60318-6, prepared by IEC TC 29, Electroacoustics, was submitted to the IEC-CENELEC parallel Unique Acceptance Procedure and was approved by CENELEC as EN 60318-6 on 2008-06-01.

This European Standard supersedes HD 590 S1:1991.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2009-03-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60318-6:2007 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60118-9	NOTE Harmonized as HD 450.9 S1:1987 (not modified).
IEC 60645-1	NOTE Harmonized as EN 60645-1:2001 (not modified).
ISO 389-3	NOTE Harmonized as EN ISO 389-3:1998 (not modified).
ISO 266	NOTE Harmonized as EN ISO 266:1997 (not modified).

CONTENTS

ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 6: Mechanical coupler for the measurement of bone vibrators

1 Scope

This part of IEC 60318 describes a mechanical coupler for the measurement of the output force of bone vibrators. The mechanical impedance of the coupler is specified in the frequency range 125 Hz to 8 000 Hz. The coupler is intended for calibration of audiometers using bone vibrators having a plane circular tip area of 175 mm² ± 25 mm² and for determining the performance of bone conduction hearing aids.

The vibratory force developed by a bone vibrator is not, in general, the same on the coupler as on a person's mastoid. However, the IEC recommends its use as a means for the calibration of specified vibrators used in audiometry and for the exchange of specifications and of data on bone conduction hearing aids.

NOTE Some bone vibrators of hearing aids and some non-standardised bone vibrators still used in audiometry have a curved surface. Users should be aware that those vibrators in general will not be loaded on the mechanical coupler with the same mechanical impedance as the one specified in Table 1 of this standard.

2 Normative reference

The following referenced document is 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.

BIPM, IEC, ISO, IFCC, IUPAC, IUPAP and OIML:1995, *Guide to the expression of uncertainty in measurement (GUM)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
bone-conduction vibrator
bone vibrator
electro-mechanical transducer that transforms electric oscillations into mechanical vibrations and is intended to be coupled to the bony structure of the head, most commonly the mastoid apophysis

3.2
mechanical coupler
device for calibrating bone-conduction vibrators designed to present a specified mechanical impedance to a vibrator applied with a specified static force, and equipped with an electromechanical transducer to enable the vibratory force level at the surface of contact between vibrator and mechanical coupler to be determined

3.3
alternating force level
ten times the logarithm to the base 10 of the ratio of the squared r.m.s. value of the alternating force transmitting the vibration to the square of the reference value of one micronewton

NOTE 1 The unit of the level re 1µN is decibel (dB).

NOTE 2 The alternating force level is also called force level.

3.4
mechanical impedance
for a sinusoidal signal, the complex quotient of the alternating force transmitting the vibration by the component of velocity of the object in the direction of the force

NOTE The unit is newton second per meter (N·s/m).

3.5
mechanical impedance level
ten times the logarithm to the base 10 of the ratio of the squared absolute value (modulus) of the mechanical impedance to the square of the reference value of one newton second per meter (Ns/m)

NOTE The unit of the level re 1 N·s/m is decibel (dB).

3.6
mechanical resistance
real part of the mechanical impedance

NOTE The unit is newton second per meter (N·s/m).

3.7
mechanical reactance
imaginary part of the mechanical impedance

NOTE The unit is newton second per meter (N·s/m).

3.8
force sensitivity
quotient of output voltage of the mechanical coupler by the applied alternating force

NOTE The unit is volt per newton (V/N).

3.9
force sensitivity level
ten times the logarithm to the base 10 of the ratio of the squared force sensitivity to the square of the reference force sensitivity of one volt per newton (V/N)

NOTE The unit of the level re 1 V/N is decibel (dB).

4 Construction

4.1 General

The mechanical coupler shall consist of a rigid mass of approximately 3,5 kg containing a force-sensing element which is surmounted by visco-elastic material having an external profile as specified in 4.4. The mechanical impedance of the assembly for uniaxial vibration which is coincident with its major axis of symmetry shall comply with the specifications in 4.2 and 4.3. The whole assembly shall be supported in such a way as to be capable of sustaining a static force of up to 6 N (including the weight of the vibrator under test, if mounted on a vertical axis) with a frequency of natural oscillation on the supports not greater than 12,5 Hz.

NOTE 1 It is recommended to include a temperature-sensing device in intimate contact with the bulk mass of the mechanical coupler, to permit correct measurement of its temperature during use and calibration (see 5.5).

NOTE 2 An example of a mechanical coupler complying with this part of IEC 60318 is described in Annex A.

In the following, the specified tolerance shall be reduced by an amount equal to the actual expanded measurement uncertainty of the test laboratory before deciding if a device conforms to this specification (see Clause 8).

4.2 Mechanical impedance level

The mechanical coupler shall present a mechanical impedance at a temperature of 23 °C having the levels specified in Table 1 within the specified tolerances, when driven by a vibrator having a plane circular tip area of 175 mm^2 and applied with a static force of 5,4 N ± 0,5 N including (when the apparatus is mounted with its axis vertical) the weight of the vibrator and of any unsupported components of the force-delivery device.

The frequencies shall be equal to the stated values in Table 1 within 1 %.

Table 1 – Mechanical impedance level

Frequency Hz	**Mechanical impedance level (reference: 1 N·s/m)** dB	**Tolerance** dB
125	48,9	± 2,5
160	47,4	± 2,5
200	45,8	± 2,5
250	44,3	± 2,5
315	42,9	± 2,5
400	41,3	± 2,5
500	39,9	± 2,5
630	38,5	± 2,5
750[a]	37,4	± 2,5
800	37,0	± 2,5
1 000	35,5	± 3,2
1 250	34,0	± 3,2
1 500[a]	32,4	± 3,2
1 600	31,9	± 3,2
2 000	29,8	± 3,2
2 500	27,8	± 3,2
3 000[a]	27,2	± 3,2
3 150	27,3	± 3,2
4 000	29,5	± 3,2
5 000	32,6	± 3,5
6 000[a]	34,4	± 3,5
6 300	34,6	± 3,5
8 000	35,1	± 3,5

[a] These frequencies are used in audiometry but are not included in the preferred series specified in ISO 266 [4] [1].

NOTE 1 Values of the mechanical impedance level and tolerances are derived from experimental data on samples of mechanical couplers.

Under similar conditions but with the static force reduced to 2,5 N ± 0,5 N, the mechanical impedance level at 250 Hz shall be 2,0 dB ± 0,9 dB below the value measured with the static force of 5,4 N.

NOTE 2 This constitutes a performance specification and the lower value of static force is not necessarily recommended to be used when testing any particular hearing-aid device.

[1] The figures in square brackets refer to the Bibliography.

4.3 Phase angle of mechanical impedance

The phase angle of the mechanical impedance of the mechanical coupler at a frequency of 250 Hz and a temperature of 23 °C shall be –63,0° ± 6,0°, when driven under the same conditions as specified in 4.2, with a static force of 5,4 N.

4.4 External geometry

The contact surface of the mechanical coupler, without an applied external static force, shall be spherical with a nominal radius of 96 mm. The exposed portion of the sphere shall be circular in shape with a minimum diameter of 35 mm. Within this diameter the surface shall be smooth and the tolerance on the spherical radius shall be ± 17 mm. Outside this diameter the external profile of the mechanical coupler shall be such as to avoid interference with any bone vibrator which it is intended to test.

5 Calibration

5.1 Reference environmental conditions

Reference temperature: 23 °C

Reference relative humidity: 50 %

NOTE The mechanical impedance and the force sensitivity of mechanical couplers designed according to this part of IEC 60318 do not depend on ambient pressure.

5.2 Calibration procedure

The manufacturer shall describe method(s) for calibrating and determining the overall stability of the mechanical coupler in an instruction manual.

The calibration shall be performed for the reference environmental conditions given in 5.1 with the following tolerances:

Temperature: ± 1 °C

Relative humidity: ± 20 %

NOTE For the purpose of calibration and elsewhere in this part of IEC 60318 where temperature is specified, the stated temperature is that of the mechanical coupler. Due to the large thermal capacity of the mass comprising the body of the device, it may take several hours to attain thermal equilibrium. It is not adequate to rely on a measurement of room temperature.

5.3 Force sensitivity level

The mechanical coupler shall be calibrated by the manufacturer in terms of its force sensitivity level at the frequencies listed in Table 1.

The electrical load conditions shall be stated.

A calibration table or a graph, together with a statement defining the uncertainty, shall be supplied with each mechanical coupler. The calibration uncertainty shall not exceed 0,4 dB for frequencies up to and including 800 Hz and 0,5 dB above 800 Hz up to and including 4 kHz nor shall it exceed 1,0 dB for frequencies up to and including 8 kHz.

NOTE 1 The mechanical impedance of an external surface at a specified location is usually measured by means of an impedance head. This device consists of an acceleration transducer and a force transducer and is driven by an external exciter (shaker). It is pressed against the surface under test with a specified static application force.

NOTE 2 Measurement of the applied alternating force usually requires compensation for the mass of material in the driving stylus of the impedance head between the calibrated force transducer and the external surface, and the instructions of the transducer manufacturer should be followed.

5.4 Mechanical impedance level

The manufacturer shall supply a table or a graph with each mechanical coupler giving the results of measurements of the mechanical impedance level at the frequencies listed in Table 1 under the conditions specified in 5.2 and 5.3.

5.5 Temperature dependence

In addition, measurements specified in 5.3 and 5.4 shall be carried out over a temperature range of at least 18 °C to 28 °C at a sufficient number of frequencies to characterise the temperature dependence of the force sensitivity level and mechanical impedance level. At each temperature the device shall be allowed to reach thermal equilibrium. The temperature of the mechanical coupler shall be measured by means of a contact thermometer at the surface of the coupler body.

NOTE These data are required purely as indicators of temperature dependence. In general, the values for the temperature dependence cannot be used directly to correct data measured at other temperatures to the reference temperature of 23 °C, as the effect of the change in mechanical impedance level on the alternating force output of the bone vibrator under test will not be known.

6 Marking and instruction manual

6.1 Marking of the mechanical coupler

Mechanical couplers complying with this standard shall be marked with the manufacturer's name or trade mark, a serial number, and reference to this part of IEC 60318 by number.

6.2 Instruction manual

The mechanical coupler shall be provided with an instruction manual which, as a minimum, shall contain the information required by Clause 5.

Notwithstanding it shall also contain the following:

a) detailed instructions which need to be followed to ensure that in use the coupler meets the requirements of this part of IEC 60318;
b) details of the recommended calibration procedure(s);
c) the limits of temperature and humidity beyond which permanent damage to the mechanical coupler may result.

7 Coupling of bone vibrator to the mechanical coupler

Means shall be provided for applying the vibrator under test to the mechanical coupler with the specified static force (see 5.3). This device shall permit the calibration of vibrators mounted on a headband or of unmounted vibrators without causing a spurious response of the vibrator.

NOTE 1 It is recommended that the mechanism for applying the static force (e.g. springs or gravity-loading mechanism) provided on the mechanical coupler be decoupled from the vibrator under test by means of elastic bands applied symmetrically to the back of the vibrator, the elastic bands having negligible stiffness in the direction of the vibration.

NOTE 2 For measurements on headband-mounted vibrators it is recommended that provision be made to open the headband so as to develop the required static force. The free end of the headband should bear on a resilient material to reduce spurious resonance effects and the headband should not act in parallel with the springs used to resiliently mount the mechanical coupler. An example of one form of mounting is shown in Figure A.2 of IEC 60118-9:1985 [1].

NOTE 3 Means should be provided for locating the vibrator symmetrically on the mechanical coupler.

8 Maximum permitted expanded uncertainty of measurements

The following table specifies the maximum permitted expanded uncertainty for a probability of approximately 95 % equivalent to a coverage factor of k = 2, associated with the measurements undertaken in this part of IEC 60318, see the *Guide to the expression of uncertainty in measurement*. One set of values for U_{max} is given for basic type approval measurements.

The expanded uncertainties of measurements given in Table 2 are the maximum permitted for demonstration of conformance to the requirements of this standard. If the actual expanded uncertainty of a measurement performed by the test laboratory exceeds the maximum permitted value in Table 2, the measurement shall not be used to demonstrate conformance to the requirements of this standard.

Table 2 – Values of U_{max} for basic measurements

Measured quantity	Relevant clause number	Basic U_{max} (k = 2)
Mechanical impedance level 125 Hz to 800 Hz	4.2	0,5 dB
Mechanical impedance level >800 Hz to 4 000 Hz	4.2	0,7 dB
Mechanical impedance level >4 000 Hz to 8 000 Hz	4.2	1,0 dB
Mechanical impedance phase at 250 Hz	4.3	1,0 °
Difference in mechanical impedance level with reduced static force of 2,5 N	4.2	0,1 dB
Static force	4.2, 5.3	0,25 N
Frequency	4.2	0,5 %
Linear dimensions	4.4	1 mm
Force sensitivity level 125 Hz to 800 Hz	5.3	0,4 dB
Force sensitivity level >800 Hz to 4 000 Hz	5.3	0,5 dB
Force sensitivity level >4 000 Hz to 8 000 Hz	5.3	1,0 dB
Temperature	5.2, 5.5	0,3 °C

Annex A
(informative)

Example of a specific construction of a mechanical coupler

A.1 Mechanical impedance elements

A.1.1 Visco-elastic components

a) Butyl rubber pad

The butyl rubber pad (Figure A.3) is in the form of a flat plate of diameter approximately 40 mm to 50 mm and thickness 3,8 mm.

b) Neoprene rubber pad

The neoprene rubber pad (Figure A.3) is in the form of a flat plate of diameter approximately 40 mm to 50 mm and thickness 3,1 mm.

A.1.2 Metal components

a) Mechanical impedance element base

The base consists of stainless steel to which a rubber part can be adhered (Figure A.1 and lower part of element A in Figure A.3). The upper surface has a spherical radius of 89,0 mm ± 0,5 mm and is free from turning marks or other blemishes.

b) Loading insert

The loading insert is in the form of a frustum of a cone of thickness 2,50 mm ± 0,05 mm, as shown in Figure A.2. The insert is turned from tungsten alloy of density 17 000 kg/m^3.

A.1.3 Assembly

To achieve the desired mechanical impedance it is essential that the neoprene rubber pad is fully adhered to the steel base and in turn that the butyl rubber pad is adhered to the neoprene rubber pad and tungsten loading insert.

A.2 General assembly

The mechanical impedance element is mounted on the brass body as shown in Figure A.3, a piezoelectric force-sensing element being clamped between them.

Dimensions in millimetres

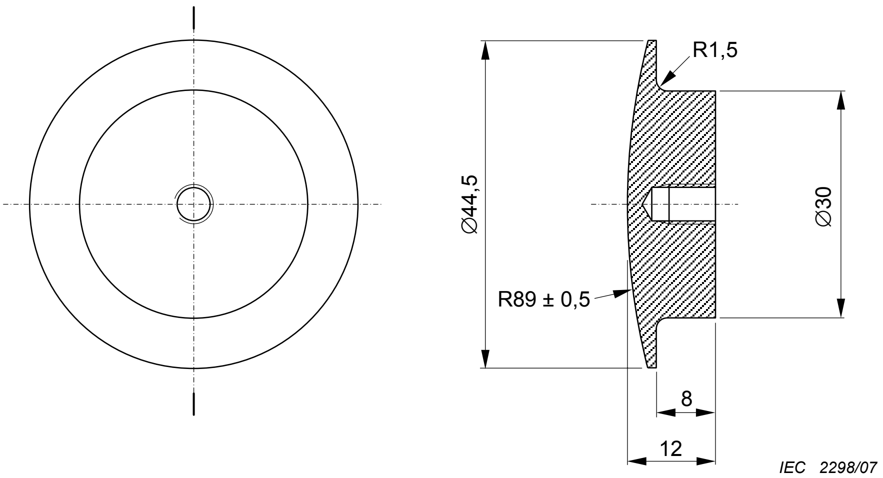


Figure A.1 – Dimensions of mechanical impedance element base

Dimensions in millimetres

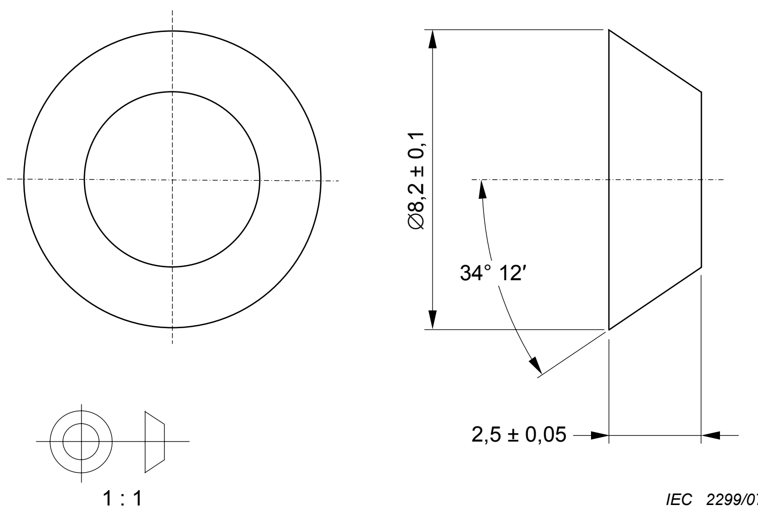
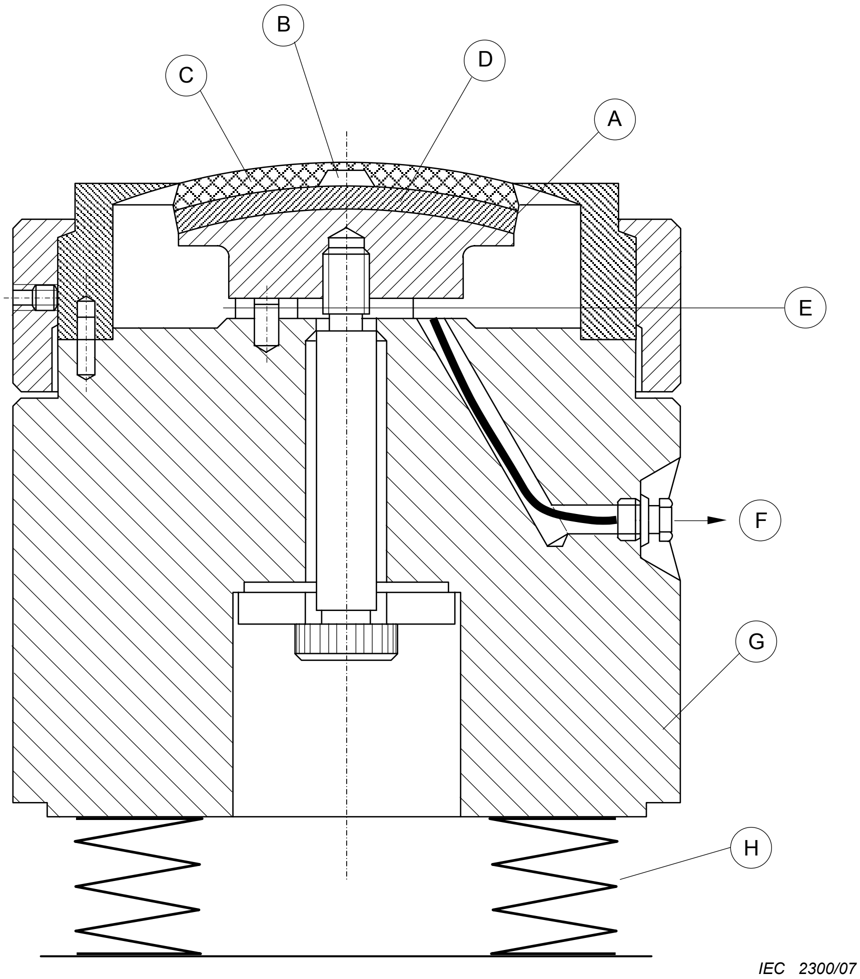


Figure A.2 – Dimensions of tungsten loading insert



Key

A Mechanical impedance element (consisting of base and impedance components)

B Tungsten loading insert

C Butyl rubber pad

D Neoprene rubber pad

E Piezoelectric force-sensing element

F Transducer output

G Cylindrical brass body

H Soft suspension

Figure A.3 – Assembly of the mechanical coupler

Annex B
(informative)

Guidance on the testing and calibration of mechanical couplers

B.1 General

These guidance notes are given in order to reduce as far as possible the measurement uncertainty of mechanical-impedance tests and force-sensitivity calibrations of mechanical couplers. These notes do not aim to give a full description of the testing and calibration methods. A prerequisite is that the accelerometer and force transducer sensitivities of the impedance head are known [15].

B.2 Preparation for the measurements

Prior to the measurements, the mechanical coupler should be stored for at least 12 hours in an environment as given in 5.2. At the beginning and at the end of the measurements, the temperature of the mechanical coupler should be measured.

The impedance head should be attached to the mechanical coupler as close as possible to the centre of and perpendicular to the visco-elastic layers in the following way: First a spirit level is used to ensure that the cylindrical brass body of the mechanical coupler is vertically positioned. Next the impedance head (mounted on the exciter) is positioned vertically in the centre of the visco-elastic layers using the required static force. The angle of contact is controlled visually by ensuring that the small opening angles between the curved surface of the visco-elastic layers and the flat surface of the driving platform of the impedance head are the same for all viewing angles.

NOTE With some samples the maximum elevation of the visco-elastic layers is not above its centre but several millimetres off the centre. In this case the cylindrical brass body of the mechanical coupler is slightly tilted by placing spacers below one or two legs of the mechanical coupler in order to be able to measure still as close as possible to the centre maintaining a perpendicular alignment.

B.3 Measurements of the mechanical impedance and the force sensitivity of the mechanical coupler

All measurements should be performed using an excitation signal giving a constant velocity of 1,0 mm/s ± 0,1 mm/s [15]. If the mass compensation is performed at one frequency only, this should be done at a frequency of 2 000 Hz.

The measurements with a static coupling force of 5,4 N should be performed first, followed by those with 2,5 N.

The force sensitivity of the mechanical coupler should be determined using a force sensitivity of the impedance head which is ideally calibrated at each corresponding frequency.

The mechanical impedance, however, should be determined using constant values (independent of frequency) for the acceleration and force sensitivities of the impedance head. The respective values at 1 kHz should be used.

NOTE The reason for such a recommendation is that the reference values in Table 1 also have been determined with constant values for the acceleration and force sensitivities of the impedance head.

Bibliography

[1] IEC 60118-9:1985, *Hearing aids – Part 9: Methods of measurement of characteristics of hearing aids with bone vibrator output*

[2] IEC 60645-1, *Electroacoustics – Audiological equipment – Part 1: Pure-tone audiometers*

[3] ISO 389-3, *Acoustics – Reference zero for the calibration of audiometric equipment – Part 3: Reference equivalent threshold force levels for pure tones and bone vibrators*

[4] ISO 266, *Acoustics – Preferred frequencies*

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
BIPM/IEC/ISO/ IFCC/IUPAC/ IUPAP/OIML	1995	Guide to the expression of uncertainty in measurement (GUM)	-	-

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