

Environmental testing —

Part 3-11: Supporting documentation and guidance — Calculation of uncertainty of conditions in climatic test chambers

The European Standard EN 60068-3-11:2007 has the status of a
British Standard

ICS 19.040

National foreword

This British Standard is the UK implementation of EN 60068-3-11:2007. It is identical to IEC 60068-3-11:2007.

The UK participation in its preparation was entrusted to Technical Committee GEL/104, Environmental conditions, classification and testing.

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.

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 August 2007

© BSI 2007

ISBN 978 0 580 54295 4

Amendments issued since publication

Amd. No.	Date	Comments

**Environmental testing -
Part 3-11: Supporting documentation and guidance -
Calculation of uncertainty of conditions in climatic test chambers
(IEC 60068-3-11:2007)**

Essais d'environnement -
Partie 3-11: Documentation
d'accompagnement et guide -
Calcul de l'incertitude des conditions
en chambres d'essais climatiques
(CEI 60068-3-11:2007)

Umgebungseinflüsse -
Teil 3-11: Unterstützende Dokumentation
und Leitfaden -
Berechnung der Messunsicherheit
von Umgebungsbedingungen
in Klimaprüfkammern
(IEC 60068-3-11:2007)

This European Standard was approved by CENELEC on 2007-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 104/409/FDIS, future edition 1 of IEC 60068-3-11, prepared by IEC TC 104, Environmental conditions, classification and methods of test, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60068-3-11 on 2007-06-01.

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) 2008-03-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2010-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60068-3-11:2007 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION.....	5
1 Scope	6
2 Normative references	6
3 Terms and definitions	7
4 Concept of uncertainty.....	10
4.1 Uncertainty, error and “true value”	10
4.2 Statements of uncertainty	11
4.3 Combining uncertainties	12
5 Tolerance	12
6 Humidity and temperature measurement	12
7 Methods for determining climatic test chamber uncertainties.....	13
7.1 Empty chamber	15
7.2 Typical load	15
7.3 Measurement of conditions in the chamber during the test.....	16
7.4 Conditions to measure	16
7.5 Measurements required	17
7.6 Sources of uncertainty	18
7.7 Essential contributions of uncertainty	19
8 Estimation of uncertainty components and their combination	23
9 Overall uncertainty of temperature measurement.....	23
9.1 General.....	23
9.2 Further considerations	25
10 Overall uncertainty of relative humidity measurement	25
10.1 Uncertainty of temperature measurement at each sensor point	26
10.2 Uncertainty of the relative humidity measurement.....	26
11 Anomalous data and presentation of results	29
11.1 Average case analysis	29
11.2 Worst case analysis.....	29
Annex A (informative) Measurement data sets – Loaded chamber.....	31
Annex ZA (normative) Normative references to international publications with their corresponding European publications.....	34
Bibliography	33

Figure 1 – Approaches to calibration method and uncertainty calculation	14
Figure 2 – Illustration of the fluctuation of a temperature sensor	22
Table 1 – Combination of temperature uncertainties	23
Table 2 – Combination of temperature uncertainties at each point.....	26
Table 3 – Combination of humidity uncertainties	27
Table A.1 – Typical temperature measurement data set and it's analysis and refs	31
Table A.2 – Humidity measurements analysis based on Table A.1 temperatures	32

INTRODUCTION

This part of IEC 60068 provides guidance for analysing uncertainties of temperature and humidity in climatic test chambers. It has been written for technicians, engineers and managers in environmental testing, and for anyone who needs to understand the results of environmental tests.

The performance of climatic test chambers is a key concern in environmental test engineering. To comply with any test specification, the performance of the chamber needs to be characterized to decide whether the generated conditions fall within the specified limits. This characterization can be a difficult task, and the analysis of uncertainties in chamber performance is often surrounded by confusion. This publication is intended to ease that process.

In what follows, the concept of uncertainty of measurement is introduced first and then the significance of tolerance discussed. Aspects of humidity and temperature measurement are considered, followed by methods for determining and combining uncertainties. The cases of both calibrating an empty chamber and of measuring conditions in a loaded chamber are considered. Finally, detailed guidance and worked examples are given for analysing results to give estimates of uncertainty in the measured performance.

ENVIRONMENTAL TESTING –

Part 3-11: Supporting documentation and guidance – Calculation of uncertainty of conditions in climatic test chambers

1 Scope

This part of IEC 60068 demonstrates how to estimate the uncertainty of steady-state temperature and humidity conditions in temperature and humidity chambers. Since this is inextricably linked to the methods of measurement, these are also described.

This standard is equally applicable to all environmental enclosures, including rooms or laboratories. The methods used apply both to temperature chambers and combined temperature and humidity chambers.

This standard is meant to help everyone using climatic test chambers. Those already familiar with uncertainty of measurement will find it useful for guidance on typical sources of uncertainty and how they should be quantified and combined. It is also intended to assist the first-time or occasional user who has little or no knowledge of the subject.

To discuss uncertainty, it is important first to understand what is being measured or characterized. The calibration or characterization of the performance of a chamber is concerned with the humidity and temperature of the air in the chamber, as experienced by the item under test, at a given set point. This should not be confused with characterizing or calibrating the chamber sensor, which is a separate matter.

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.

IEC 60068-3-5: *Environmental testing – Part 3-5: Supporting documentation and guidance – Confirmation of the performance of temperature chambers*

IEC 60068-3-6: *Environmental testing – Part 3-6: Supporting documentation and guidance – Confirmation of the performance of temperature/humidity chambers*

ISO 3534-1:2006, *Statistics – Vocabulary and symbols – Part 1: General statistical terms and terms used in probability*

ISO 3534-2:2006, *Statistics – Vocabulary and symbols – Part 2: Applied statistics*

International Vocabulary of basic and general standard terms in metrology. ISO, Geneva, Switzerland 1993 (ISBN 92-67-10175-1) – VIM

Guide to the expression of uncertainty in measurement. ISO, Geneva, Switzerland 1993.
(ISBN 92-67-10188-9) – GUM

3 Terms and definitions

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

3.1

calibration authority

laboratory or other organization that performs calibrations and is itself accredited by the appropriate national accreditation body

3.2

climatic test chamber

enclosure

chamber or enclosed space where the internal temperature or temperature and humidity can be controlled within specified limits

3.3

combined standard uncertainty

standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of a sum of terms, the terms being the variances or covariances of these other quantities weighted according to how the measurement result varies with changes in these quantities

See also GUM.

3.4

correction

value added algebraically to the result of a measurement to compensate determinable systematic error

See also VIM.

3.5

confidence level

value of probability associated with a confidence interval

NOTE The confidence level is the likelihood that the “true value” lies within the stated range of uncertainty usually expressed as a percentage, e.g. 95 %.

See also ISO 3534-1.

3.6

coverage factor

numerical factor to multiply the combined standard uncertainty to obtain an expanded uncertainty

NOTE A coverage factor of $k=2$ corresponds to a confidence level of approximately 95 % if normally distributed and if the number of degrees of freedom is sufficiently large.

See also GUM.

3.7**dew point**

temperature at which the partial pressure of the water vapour is equal to the saturation vapour pressure over water or ice

NOTE The temperature to which the air would have to cool (at constant pressure and constant water vapour content) in order to reach saturation. A state of saturation exists when the air is holding the maximum amount of water vapour possible at the existing temperature and pressure.

3.8**dispersion**

spread of repeated measurements of a quantity

3.9**drift**

change in the indication of a measuring system not related to a change in the quantity being measured

See also VIM.

NOTE The drift since the last calibration can be estimated and a correction applied to measured values.

3.10**error**

difference between result of a measurement and the true value

3.11**expanded uncertainty**

quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

See also VIM.

3.12**fluctuation**

change (from the mean) in the temperature or humidity after stabilization from time to time at a point in space

NOTE It may be measured by standard deviation or maximum deviation.

3.13**gradient**

maximum difference in mean value, after stabilization, at any moment in time between two separate points in the working space

3.14**incident air**

conditioned airstream which flows into the working space

3.15**partial vapour pressure**

contribution of water vapour in a given volume of air at a constant pressure and temperature of the atmosphere

3.16**reference instrument**

previously calibrated instrument used to measure the conditions within the enclosure

3.17

relative humidity

ratio of actual partial vapour pressure to the saturation vapour pressure at any given temperature and pressure, expressed as a percentage (% RH)

3.18

repeatability

closeness of agreement between independent results obtained in the normal and correct operation of the same method on identical test material, in a short space of time, and under the same test conditions (such as the same operator, same apparatus, same laboratory)

3.19

resolution

smallest changes between indications of the chamber controller display that can be meaningfully distinguished

3.20

saturation vapour pressure

when a given volume of air, at a constant temperature, has water vapour present and is incapable of holding more water vapour it is said to be saturated

3.21

stabilization

achievement of the state of temperature/humidity in the chamber when all mean values in the working space are constant and have maintained temperature/humidity within a given tolerance

3.22

standard deviation

measure of the dispersion of a set of measurements

NOTE The standard deviation, s , is the best estimate of sigma (the population standard deviation).

See also GUM and/or VIM.

3.23

standard uncertainty

uncertainty of the result of a measurement expressed as a standard deviation

See also GUM.

3.24

tolerance

acceptance limit specified or chosen for a process or product

See also ISO 3534-2.

3.25

traceability

property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons, all having stated uncertainties

NOTE The unbroken chain of comparisons is called a traceability chain.

See also ISO 3534-1 and VIM.

3.26**true value**

value which characterizes a quantity, perfectly defined in the conditions which exist when that quantity is considered

NOTE The true value of a quantity is a theoretical concept and, in general, cannot be known exactly but is estimated by measurement.

See also ISO 3534-1.

3.27**uncertainty**

parameter, associated with the result of a measurement, which characterizes the dispersion of the values that could reasonably be attributed to it

3.28**uncertainty budget**

list of sources of uncertainty compiled with a view to evaluating a combined standard uncertainty associated with a measurement result

3.29**uncertainty contribution**

input to an uncertainty budget

3.30**working space**

part of the chamber in which the specified conditions can be maintained within the specified tolerances

4 Concept of uncertainty**4.1 Uncertainty, error and “true value”**

In every measurement – no matter how careful – there is always a margin of doubt about the result. In simple terms, the uncertainty of a measurement is a quantification of the doubt about the measurement result.

While discussing uncertainty we often also need to consider a related but separate concept, “error”. A measurement “error” is the difference between the measured value and the “true value” of the thing being measured.

The “true value” of any quantity is in principle unknowable. This leads to a problem since the “error” is defined as the result of a measurement minus the “true value”. Sometimes this difference can be estimated. Both terms are best avoided as much as possible and, when necessary, should be used with care. Discussion of “error analysis”, which used to be included in many scientific papers, should have been entitled “analysis of the probable limits of error”, or more properly, “analysis of uncertainty”. In older publications the term “error” was widely used when ‘uncertainty’ would have been the correct term.

Uncertainty is not the same as error. If the conditions in a test chamber are measured with a calibrated instrument and the result is 75 % RH when the chamber controller says 90 % RH, that does not mean the uncertainty is 15 % RH. It is known that the relative humidity is 75 % RH. One is aware that either the controller reading is wrong or the chamber is operating incorrectly. It has an error estimated to be 15 % RH. The uncertainty is a characteristic of the measurement that gave the answer 75 % RH. Could that be wrong and, if so, by how much?