EURAMET

European Association of National Metrology Institutes

Calibration of Temperature and/or Humidity Enclosures

EURAMET cg-20

Version 4.0 (02/2015)

Calibration Guide

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Calibration of Temperature and / or Humidity Controlled Enclosures

Purpose

This document has been produced to enhance the equivalence and mutual recognition of calibration results obtained by laboratories performing calibrations of climatic chambers.

This document was developed by the EURAMET e.V., Technical Committee for Thermometry.

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Official language

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Guidance Publications

This document gives guidance on measurement practices in the specified fields of measurements. By applying the recommendations presented in this document laboratories can produce calibration results that can be recognized and accepted throughout Europe. The approaches taken are not mandatory and are for the guidance of calibration laboratories. The document has been produced as a means of promoting a consistent approach to good measurement practice leading to and supporting laboratory accreditation.

The guide may be used by third parties e.g. National Accreditation Bodies, peer reviewers witnesses to measurements etc., as a reference only. Should the guide be adopted as part of a requirement of any such party, this shall be for that application only and EURAMET secretariat should be informed of any such adoption.

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Further information

For further information about this document, please contact your national contact person of the EURAMET Technical Committee for Thermometry (see www.euramet.org).

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1 Introduction

Calibration practices in the laboratories are in many cases based on national or international standards, which are quite similar in general, but show differences in detail and are written for different purposes and different readers. The most important standards and technical guidelines are outlined below

- DKD-R 5-7: Calibration of Climatic Chambers.(2004) English Translation (2007)
- IEC 60068 series on environmental testing, in particular
  - IEC 60068-3-5 – Environmental Testing – Part 3-5: (2001)
    BS EN 60068 -3-5(2002)
    Confirmation of the Performance of Temperature Chambers.
  - IEC 60068-3-6 – Environmental Testing – Part 3-6: (2001)
    BS EN 60068 -3-6(2002)
    Confirmation of the Performance of Temperature/Humidity Chambers.
  - IEC 60068-3-7 – Environmental testing – Part 3-7: (2001)
    BS EN 60068 -3-7(2002)
    Measurements in Temperature Chambers for Tests A and B (with load)
  - IEC CEI 60068-3-11 – Environmental Testing – Part 3-11: (2007)
    Calculation of Uncertainty of conditions in Climatic Test Chambers
  - AFNOR NF X 15-140 – (2002):
    Mesure de l'humidité de l'air Measurement of Air Humidity
    Enceintes climatiques et thermostatiques - Caractérisation et vérification
    Climatic and Thermostatic Chambers. Characterisation and Verification

In addition, the following standards are referred in the standards above :

- IEC 60584-1 Thermocouples – (1995) Part 1 Reference Tables
- IEC 60751. (2008) Industrial Platinum Resistance Thermometers Class A

A summary on the scope of these standards and guidelines is given in Appendix A of this document.

2 Scope

The purpose of this EURAMET Calibration Guide is to outline the basic technical requirements for those laboratories undertaking the calibration of climatic chambers and to harmonize calibration practices applied in the calibration of climatic chambers to obtain reliable and widely recognized calibration results. It is not the aim to replace or to harmonize the existing standards.

This Calibration Guide is also recommended for the Accreditation Bodies when accrediting laboratories for the calibration of climatic chambers.

3 General Comments

Calibration of a climatic chamber in principle is the determination of the deviation between the indication on the display values of the chamber and the corresponding values measured in the chamber. The characterisation of other parameters like air temperature/humidity spatial distribution in the specified calibration volume, air temperature/humidity temporal stability over a representative period of time, thermal inertia, recovery time, etc can also be specified in the calibration scope of a laboratory.

On the other hand, the calibration of the indication of a climatic chamber is by far not the best method for documenting the environmental condition during the operation of a climatic chamber. The use of at least one sensor for temperature and/or humidity in close proximity with the load in the chamber usually will provide much more reliable data than the indication of the climatic chamber. Calibration laboratories should inform their customers about this fact, preferably before signing the contract with the customer. This can be done by sending the leaflet given in Annex A of this guideline to the customer.

To reduce costs, a customer may ask for a calibration at a single measurement point at one location in the chamber (one point calibration). In some cases this may be an appropriate approach but mostly calibration should be more extensive to meet the requirements of customer's activities with the chamber. Therefore, it is highly important to clearly state the coverage of the calibration in the corresponding calibration certificate.

The Laboratory and customer have to agree the scope of the calibration requested, duration of the test, (previous stabilization and recording time), parameters to be determined (calibration of the set point, study of spatial distribution of temperature/humidity, study of temporal stability, etc.) loading conditions, etc. These calibration conditions have to be recorded by the laboratory.

It is strongly recommended that if a chamber is characterised for the first time or modified that it should be calibrated/characterised with both an empty and full load.

4 Calibratability of Climatic Chamber

A laboratory performing calibrations should specify the criteria for accepting a climatic chamber to be calibrated. The criteria should be set for the volume of measurement in the chamber, control system of the measurement parameters and technical documentation of the chamber (e.g. the list in Section 5 of DKD-R-5-7 can be applied). Reference to technical guidelines is recommended. .

The usual calibration of climatic chambers is restricted to chambers operated at normal pressure. The calibration of autoclaves and similar instruments requires additional specifications, which are not described in the above mentioned standards and guidelines and do not form part of this guideline.

5 Parameter contributing to the Uncertainty

The calibration of a climatic chamber requires at least the determination of the following parameters, which will be considered also in the uncertainty budget:

- Air temperature/humidity spatial distribution in the specified calibration volume
- Air temperature/humidity temporal stability over a representative period of time
- Uncertainties associated with the working standard used for the calibration
- Radiation effect associated with the emissivity of the temperature sensor and sensor dimension, (ie diameter≥4mm), See DKD-R-5-7.Section 7.4 and NF X 140,Section13.1) caused by different temperatures of the walls of the chamber and the air in the chamber. At certain temperatures this can be the largest uncertainty component
- Time dependent temperature differences between air, measuring probe(s) and load in the chamber
- Sensitivity to temperature changes with probes placed in air or in a buffer(liquid, block) in chamber
- Influence of the loading of the chamber to the spatial distribution and temporal stability of air temperature and humidity
- Influence of ambient conditions
- Resolution of indicators

The measurement procedures of the calibration laboratories shall describe how the contributions to the uncertainty resulting from these parameters are determined. In some cases a reference to a national or international standard may fulfil this requirement.

6 Expressing Scope of Calibration

The scope declared by a laboratory for calibrations of climatic chambers should state the parameters of the chamber e.g.

- Air temperature in an empty working-volume
- Air temperature in a loaded working-volume
- Air humidity in an empty working-volume
- Air temperature at a single spot in the chamber
- Specify measurement of probe in air or buffer(Liquid, Block)

There should be a clear indication (e.g. a foot note) that the achievable uncertainty for an empty chamber is smaller than for a chamber with a load. There should also be a statement stating that the uncertainty has/has not included the radiation effect

7 Calibration Certificate

Together with the general requirement of ISO/IEC 17025 with respect to the issue of a calibration certificate, the reports related to the calibration of a climatic chamber have to include at a minimum the following information:

- Details of the working condition parameters of the chamber used during the Calibration (PID, etc)
- Details of the specific volume calibrated and distribution of the sensors(i.e.diagram)
- Characteristics of the loading, in case the calibration was performed in this condition
- If the results of the sensors are used to determine other parameters, i.e temperature / humidity spatial distribution or temperature/humidity temporal stability, it is necessary to define such parameter and the way it was calculated, together with it's measurement uncertainty.

8 Proficiency Testing

It is vital for a calibration laboratory to obtain evidence on its competence through proficiency tests and intercomparisons. The calibration of a climatic chamber is usually done in the premises of the customer, i.e. as a field calibrations (except for the initial calibration at the manufacturer). Therefore, it is recommended that a well characterized climatic chamber in an independent institute is used for proficiency testing. It is also very useful to control the performance of different calibrators within a laboratory by internal comparisons.

9 References

S. Friederici, E. Tegeler, Radiation effects and its consequences on measurements in climatic chambers, in: D. Zvizdic (ed.), Proc. TEMPMEKO 2004, vol. 2, pp. 795-800

Attached Documents

Annex A: Supplement to the Calibration Certificate for Climatic Chambers

Appendix A: Standards and Guidelines

Annex A: Supplement to the Calibration Certificate for Climatic Chambers

Information of the EURAMET Technical Committee "Thermometry"
on the calibration and use of Climatic Chambers

General

Unless stated otherwise in the calibration certificate, the calibration is valid only for the air temperature and humidity in the empty useful volume of the climatic chamber.

Under ambient conditions of measurement other than those stated, considerable deviations (up to several kelvin) from the calibration value can in part be reckoned with.

It is strongly recommended to install temperature and/or humidity sensors in close contact to the load in the chamber. These sensors usually provide a much more realistic data on the condition in the chamber than the indication of the chamber, which has been calibrated.

Radiation effects

When climatic chambers are used in the temperature range above room temperature, the temperature of the walls of many models is lower than that of the air. Due to radiation losses, the air temperature then is higher than the temperature of a thermometer or test object in the useful space.

Also, the temperature of the thermometer and that of an object in the climatic chamber can differ considerably. Especially if the emissivity or emittance (ε) of the object differs from that of the thermometer, great differences are to be reckoned with.

According to the law of radiation, the influence of this effect increases over proportionally at higher temperatures. Below room temperature, the effect is inverse but the impact is considerably smaller and often negligible.

Depending on the model of the climatic chamber, differences of several kelvin are possible above 150 °C.

Object in the useful volume

Objects in the useful volume will in general not assume the air temperature prevailing during calibration because

1) the conditions of loading - unless exactly simulated for the calibration - influence or change the temperature field in the useful volume,
2) position, size and material of the object are in general not in conformity with the characteristics of the thermometer used for the calibration of the climatic chamber, and
3) in qualitative but not in quantitative terms, the object and the thermometer are subjected to comparable $\rightarrow$ radiation effects.

Relative humidity in the useful volume

The distribution of the relative humidity in the useful volume may change considerably if there are water vapour sources or sinks in the useful volume, if effective mixing of the useful volume is not ensured or if leaks lead to air being exchanged with the environment. Relative humidity is also highly dependent on temperature.

Measurement uncertainty

The measurement uncertainty stated is valid only if the measurement conditions documented in the specific case are complied with. It is valid for the temperature or humidity indication of the climatic chamber in relation to the temperature or relative humidity of the air in the climatic chamber in a defined position or for a defined volume.

Only if the state of loading, the measuring location(s) or the useful volume, respectively, are identical and if the thermometer characteristics are similar ($\varepsilon < 0{,}2$) can the calibration value be reproduced within the measurement uncertainty stated.

The remaining radiation effect of the standard used, related to the climatic chamber calibrated here, was determined and allowed for in the measurement uncertainty. Unless expressly stated in the calibration certificate, a correction for this effect was not applied.

Appendix A: Standards and Guidelines

- **DKD-R 5-7: Calibration of Climatic Chambers**.(2004) English Translation (2009)

This guideline lays down minimum requirements for the calibration procedure and for the determination of the measurement uncertainty in the calibration of climatic chambers. It is applicable to the calibration of climatic chambers for air temperature and relative air humidity or only for air temperature. It applies to chambers both with and without a load with a useful volume. It applies to the calibration of individual measuring locations in climatic chambers; in this case the *complete* chamber is considered *not* to be calibrated. Annex A identifies two sample budgets for both temperature and humidity in relation to their useful volume.

- **IEC 60068-3-5 – Environmental Testing – Part 3-5: (2001)**
  BS EN 60068 -3-5(2002)
  Confirmation of the Performance of Temperature Chambers.

This part of the IEC 60068 applies to end users of climatic chambers. It provides a uniform and reproducible method of confirming that temperature test chambers, *with an empty working space* conform to the requirements specified in climatic test procedures of IEC 60068-2. This standard is intended for users when conducting regular chamber performance monitoring.

- **IEC 60068-3-6 – Environmental Testing – Part 3-6: (2001)**
  BS EN 60068 -3-6(2002)
  Confirmation of the Performance of Temperature/Humidity Chambers.

This part of IEC 60068 provides a uniform and reproducible method of confirming that temperature and humidity chambers *without* a load conform to the requirements, specified in climatic test procedures in IEC 60068-2. This standard is intended for users when conducting regular chamber performance monitoring.

- **IEC 60068-3-7 – Environmental testing – Part 3-7: (2001)**
  BS EN 60068 -3-7(2002)
  Measurements in Temperature Chambers for Tests A and B (with load)

This part of IEC 60068 provides a uniform and reproducible method of confirming that temperature test chambers with a load of either heat-dissipating or non heat-dissipating specimens under conditions which take into account air circulation inside the working space of the chamber conform to the requirements, specified in climatic test procedures in IEC 60068-2-1 and IEC 60068-2-2. This standard is intended for users when conducting regular chamber performance monitoring.

- **IEC CEI 60068-3-11 – Environmental Testing – Part 3-11: (2007)**
  Calculation of Uncertainty of conditions in Climatic Test Chambers

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, three basic methods for determining temperature and humidity conditions and their associated uncertainties in a climatic test chamber are described.(See Section 7)

The approach of this standard to the calibration or characterization of the performance of a chamber is an end user approach, 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.

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. The cases of both calibrating an *empty chamber* and of measuring conditions in a loaded chamber are considered.

- **AFNOR NF X 15-140 – (2002)**

Mesure de l'humidité de l'air Measurement of Air Humidity
Enceintes climatiques et thermostatiques - Caractérisation et vérification
Climatic and Thermostatic Chambers. Characterisation and Verification

The scope of this document is to define and describe the criteria to characterize and verify a chamber, together with the methodology and measures to be used. It applies to chambers with or without forced air circulation designed to conduct tests at atmospheric pressure in a thermostatic or climatic environment. Calculation of uncertainty of each sensor is determined in Appendix D.

- **Temperature Sensors**
  IEC 60584-1 Thermocouples –Part 1 (1995)
  IEC 60751 Industrial Platinum Resistance Thermometers Class A

IEC 60068-3-5 Section 4.2, IEC 60068-3-6 Section 4.4.1, IEC 60068-3-7 Section 4.1, and AFNOR NF X 15-140 state that, normally the type of sensor to be used should be the resistance type in accordance with IEC 60751 or the thermocouple type
(in accordance with IEC 60584-1) The 50% response time in air of the sensor shall be between 10 and 40s. The response time of the overall system should be less than 40 s.

In a temperature range range from -200ºC to 200ºC the sensor measurement uncertainty should be in accordance with class A of IEC 60751