

INTERNATIONAL STANDARD



Environmental testing – Part 3-1: Supporting documentation and guidance – Cold and dry heat tests



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTAL TESTING –

**Part 3-1: Supporting documentation and guidance –
Cold and dry heat tests**

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60068-3-1:2011. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60068-3-1 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) information relating to specimen temperatures has been revised;
- b) information relating to tests of multiple specimens has been revised;
- c) the effect of air density has been added;
- d) a recommendation for corrective actions regarding IR radiation has been added;
- e) the requirements for the mounting and supports of the specimen have been revised.

The text of this International Standard is based on the following documents:

Draft	Report on voting
104/986/FDIS	104/1002/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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ENVIRONMENTAL TESTING –

Part 3-1: Supporting documentation and guidance – Cold and dry heat tests

1 Scope

This part of IEC 60068 provides guidance regarding the performance of cold and dry heat tests.

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 60068-1, Environmental testing – Part 1: General and guidance~~

~~IEC 60068-2-1, Environmental testing – Part 2-1: Tests – Test A: Cold~~

~~IEC 60068-2-2, Environmental testing – Part 2-2: Tests – Test B: Dry heat~~

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

heat-dissipating specimen

specimen on which the hottest point on its surface, measured in free-air conditions and under the air pressure as specified in IEC 60068-1, is more than 5 K above the ambient temperature of the surrounding atmosphere after thermal stability has been reached

[SOURCE: IEC 60068-1:2013, 3.6, modified – The definition has been slightly adapted and Note 1 to entry has been deleted.]

3.2

non heat-dissipating specimen

~~specimen that does not produce heat to a level that can affect the air temperature surrounding the specimen or those specimens located nearby~~

specimen on which the hottest point on its surface, measured in free-air conditions and under the air pressure as specified in IEC 60068-1, is equal or less than 5 K above the ambient temperature of the surrounding atmosphere after thermal stability has been reached

3.3

free-air conditions

conditions within an infinite space where the movement of the air is affected only by the heat-dissipating specimen

Note 1 to entry: Free-air conditions can apply to the laboratory environment. The conditions during the measurement should be stated in the test report (if not specified otherwise).

[SOURCE: IEC 60068-1:2013, 3.7, modified – In the preferred term "free" has been added, in the definition "itself" has been deleted and the Note 1 to entry has been added.]

4 Selection of test procedures

4.1 General background

4.1.1 General

Specimen performance ~~may~~ can be influenced or limited by the temperatures in which the specimen is operated. The level of influence ~~may~~ can be affected by test gradients that exist within the test system (climatic or environmental chamber) and internal temperatures within the specimen itself. In order to determine the level of influence that exists and to ensure that the specimen is designed appropriately, cold ~~and/or~~ dry heat tests or both are performed.

4.1.2 Ambient temperature

The maximum and minimum ambient temperature values, ~~where in which~~ the specimen ~~will be subjected~~ is intended to operate, should be known. Preferred values for testing purposes are provided in IEC 60068-2-1 or IEC 60068-2-2 or both.

Difficulties can arise due to the fact that heat transfer causes temperature variations in the area surrounding the specimen. Consequently, the effect from the transfer of heat to the ambient temperature of the surrounding atmosphere should be considered. Airflow related to spacing between specimens should also be considered when performing a test.

4.1.3 Specimen temperatures

The performance of the specimen can be affected by its own temperature in the case of heat-dissipating specimens. Because of this, when controlling the test environment, it ~~may~~ can be necessary to measure the temperature of the specimen under test at different locations, both internally and externally.

The change of temperature at a point on the surface of a specimen follows approximately an exponential law. Inside large specimens, temperature equalization can be reached with significant delay.

In case of doubt, how the temperature change is reflected by the specimen, the monitoring of the temperature of the specimens at a representative point (or points) is recommended.

NOTE For further information on the influence of test temperatures on specimens, IEC 60068-2-14 or IEC 60068-3-11 can be helpful.

4.1.4 ~~Specimens without heat dissipation~~ Non heat-dissipating specimens

If the ambient temperature is uniform and constant and there is no generation of heat within the specimen, heat will flow from the ambient atmosphere into the specimen if the ambient atmosphere is at a higher temperature. Conversely, heat will flow from the specimen into the ambient atmosphere if the specimen is at a higher temperature. This heat transfer will continue until the specimen has completely reached thermal equilibrium with the surrounding atmosphere. From that moment on, the heat transfer ceases and will not start again unless the ambient temperature changes.

4.1.5 ~~Specimens with heat dissipation~~ Heat-dissipating specimens

If heat is generated within the specimen, the temperature of the specimen will rise to a stabilization point above the ambient temperature. It follows that if a steady temperature is reached, heat will flow continuously from the specimen by convection, radiation, and/or conduction into the atmosphere whereby the specimen is cooled.

If more than one specimen is subjected to a dry heat test in the same chamber, it is necessary to ensure that all specimens are in the same ambient temperature and have identical mounting conditions. ~~It has not, however, been found~~ It can become necessary to differentiate between testing of single specimens and multiple specimens when the cold test is being performed.

NOTE If more than one specimen is tested in the same test chamber, a uniform incoming airflow can be disturbed.

4.2 Mechanisms of heat transfer

4.2.1 Convection

Heat transfer through convection is an important factor when testing heat-dissipating specimens. The coefficient of heat transfer from the surface of the test specimen to the ambient air is affected by the velocity and density of the surrounding air. The greater the air velocity, the more efficient the heat transfer is. Therefore, the higher the air velocity, the lower the surface temperature of the test specimen will be with the same temperature of the ambient air. This effect is illustrated in Figure 1 and Figure 2.

Air density also has a significant influence on heat transfer. Cold air is denser than warm air. Therefore, hot air causes a lower heat transfer than cold air.

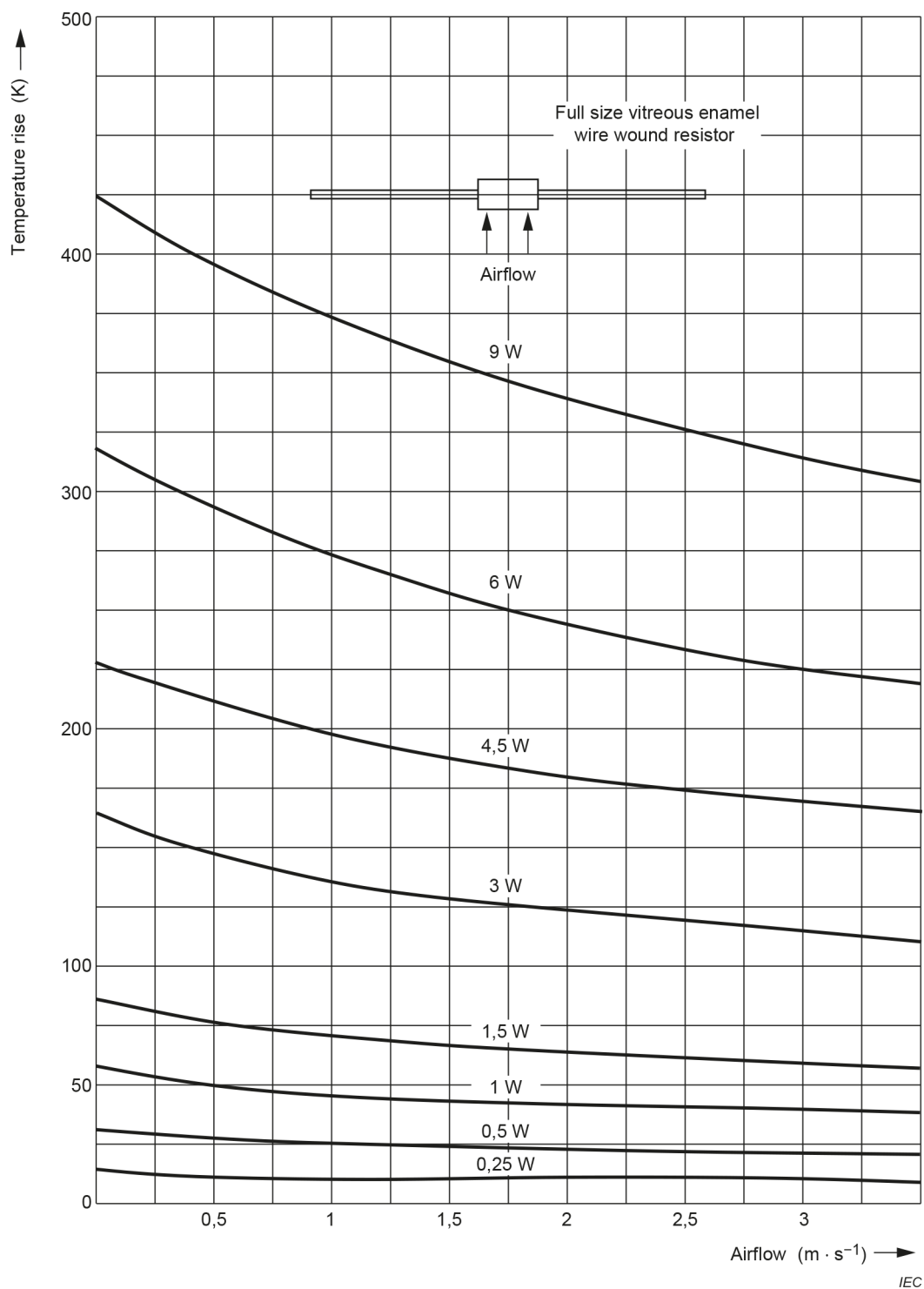


Figure 1 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Radial airflow

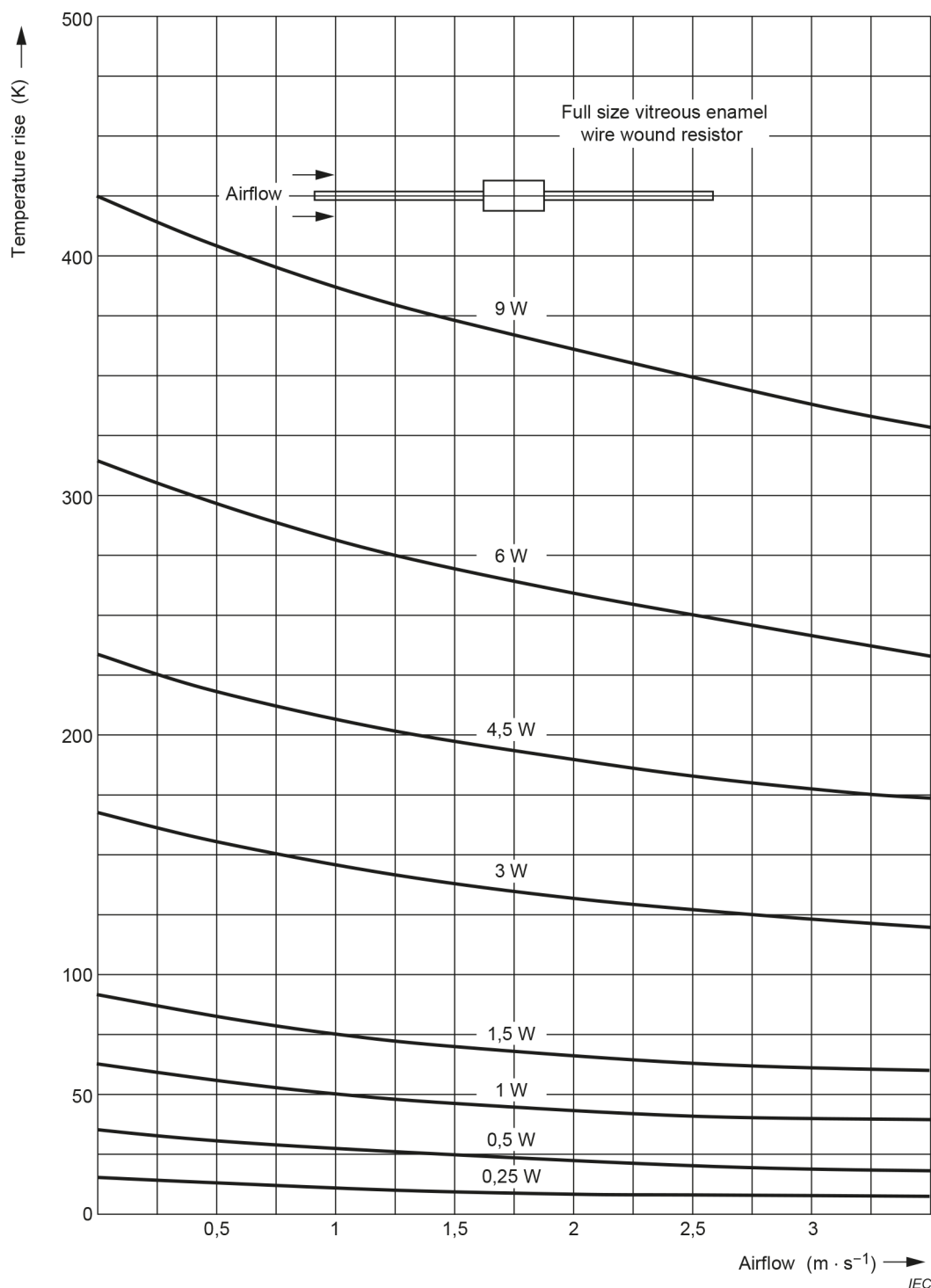
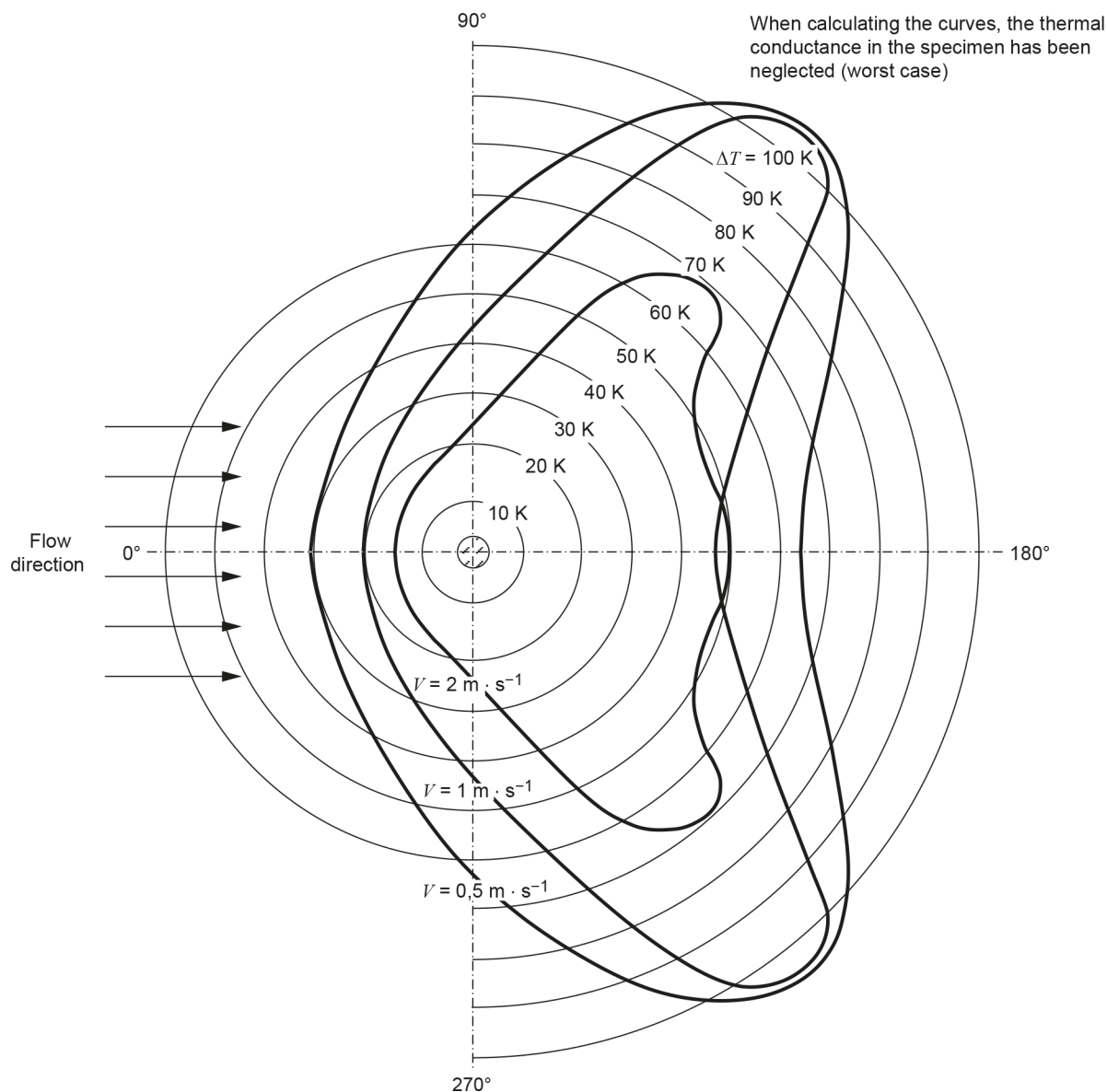


Figure 2 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Axial airflow

In addition to the influence on the surface temperature of the test specimen, the airflow within the chamber will also affect the temperature distribution over the surface of the specimen under test. This effect is illustrated in Figure 3.

Therefore, when testing heat-dissipating specimens, the effects of airflow around or over the specimen should be known to ensure that the conditions approximate as close as possible typical free-air conditions or those conditions expected when the specimen is in use.



ΔT is the rise in surface temperature of the specimen above ambient

V air velocity $\text{m} \cdot \text{s}^{-1}$

Air temperature 70°C

Cylinder diameter 6 mm

Heat-dissipation per unit of surface area $1,5 \text{ kW} \cdot \text{m}^{-2}$

IEC

Figure 3 – Temperature distribution on a cylinder with homogeneous heat generation in airflow of velocities (0,5, 1 and 2) $\text{m} \cdot \text{s}^{-1}$

4.2.2 Radiation

Heat transfer by thermal radiation cannot be neglected when test chamber conditions for testing of heat-dissipating specimens are considered. In a "free air" condition, the heat transferred from the test specimen is absorbed by its surroundings.

Corrective actions should be considered to minimize the effect of IR radiation.

NOTE IR radiation through the chamber window (observing window) can impact the specimen's temperature. This effect can be increased by radiation heating systems in the laboratory or windows in the laboratory allowing IR radiation of the sun to enter the test space.

4.2.3 Thermal conduction

Heat transfer by thermal conduction depends on the thermal characteristics of mounting and other connections. These should be known in advance of the test.

Many heat-dissipating specimens are intended to be mounted on heat sinks or other well-conducting elements, with the result that a certain amount of heat is effectively transferred through thermal conduction.

The relevant specification ~~shall~~ **should** define the thermal characteristics of the mounting and these characteristics should be reproduced when the test is made.

~~If a specimen can be mounted in more than one manner with different values of thermal conduction, the mounting device with the lowest thermal conductivity for dry heat tests on a specimen with heat dissipation and the mounting device with the highest thermal conductivity for all the other tests (dry heat tests on specimens without heat dissipation, cold tests on specimens with or without heat dissipation) should be used.~~

The thermal conduction of the mounting or supports should be low, such that for practical purposes the specimen is thermally isolated, if not specified otherwise. When testing several specimens simultaneously they should be so placed that free circulation is provided between specimens, and between specimens and chamber surfaces.

4.2.4 Forced air circulation

To verify that the temperature at representative points on the surface of the test specimen is not unduly influenced by the air velocity used in the chamber, measurements should be made with the specimen inside the chamber, with the chamber operating at standard atmospheric conditions for measurement and tests (see IEC 60068-1). If the surface temperature at any point of the test specimen is not reduced by more than 5 K by the influence of the air circulation used in the chamber, the cooling effect of the forced air circulation ~~may~~ **can** be ignored.

Where the reduction of surface temperature exceeds 5 K, the temperatures from a representative number of points on the surface of the test specimen should be measured in order to give a basis for calculation of the surface temperatures at the specified test conditions. These measurements should be carried out under those load conditions which are specified for the test temperature by the relevant specification.

For small temperature differences below 5 K between the ambient temperature and surface temperature of the specimen, the surface temperature can be assumed to be the same when tested at different ambient temperatures.

The choice of representative points to be checked should be based on a detailed knowledge of the test specimen (thermal distribution, thermally critical points, etc.). A single chamber characterization ~~may~~ **can** cover the chamber performance for a long series of the same type of tests with similar specimens, whereas in other cases **it can be necessary** for a characterization ~~may need~~ to be made prior to each test for different types of specimens.

4.3 Test chambers

4.3.1 General

Even in very large chambers, the air circulation and temperature distribution around the test specimen will not be identical with actual free-air conditions. It is not practical for testing purposes to try to reproduce free-air conditions, but it is possible to simulate the effects of these conditions. Nevertheless, it is established by experimental results and test experience that a reasonably large chamber with low air flow through the workspace will affect the temperature of the test specimen in approximately the same way as would free-air conditions.

Table 1 lists the parameters of a test chamber that should be considered when testing heat-dissipating specimens.

Table 1 – Influence parameters when testing heat-dissipating specimens

Transfer mechanism	Convection		Radiation	Conduction
	Free air	Forced air circulation		
Chamber parameter	Chamber dimensions	Chamber dimensions, air velocity	Emissivity of the chamber walls	Thermal characteristic of mounting

4.3.2 Methods of achieving the required conditions in the test chamber

4.3.2.1 Design of chambers for simulating the effect of free-air conditions

Heating and cooling components used to control the temperature of the working space should not be placed in the working space.

4.3.2.2 Design of chambers with forced air circulation

The airflow should be as uniform as possible and should be directed in such a way to minimize the variation that would occur due to convection. The effects of airflow are given in more detail in Annex A.

4.4 Measurements

4.4.1 Temperature

Measurement of the temperature at various points on or in a specimen are recommended for tests involving heat-dissipating specimens in conditions other than "free air". The choice of representative points should be based on a detailed knowledge of the test specimen (thermal distribution, thermally critical points, etc.).

4.4.2 Air velocity

The velocity of the air in the test chamber should be known to ensure uniformity of conditions within the chamber in the case of testing multiple specimens in the same chamber. Measurements should be made based on the working space within the chamber and the size and shape of the test specimen.

If more than one specimen is tested in the same test chamber, a uniform incoming airflow can be disturbed. It should be taken into consideration that one specimen can shield the other.

Annex A (informative)

Effect of airflow on chamber conditions and on surface temperatures of test specimens

A.1 Calculation

For the calculation of the effect of airflow on a specimen temperature and on the temperature gradient in the chamber the following symbols are used, where:

- V is the air velocity ($\text{m} \cdot \text{s}^{-1}$);
- $\lambda(V)$ is the heat transfer coefficient ($\text{W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}$);
- P is the quantity of heat transferred in unit time (W);
- F is the effective area of the heat-dissipating surface (m^2);
- t is the time (s);
- G is the mass of incoming or outgoing air per unit time ($\text{kg} \cdot \text{s}^{-1}$);
- C_p is the specific heat of air at constant pressure ($1\,000 \text{ J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$);
- γ is the density of air ($1,29 \text{ kg} \cdot \text{m}^{-3}$);
- S is the cross-sectional area of the chamber (m^2);
- T is the temperature (K).

A.2 Specimen temperature

The following equation expresses a specimen temperature:

$$T = \frac{1}{\lambda(V)} \times \frac{P}{F}$$

where

$$\lambda(V) = a + bV$$

$$a \cong 10$$

$$V < \frac{a}{b} < 3 \text{ m} \cdot \text{s}^{-1}$$

Experimental results indicate that, at the low air velocities relevant to the tests, $b \cong 3$; b increases with increasing air velocity until at $3 \text{ m} \cdot \text{s}^{-1}$, $b \cong 8$.

If $V = 0,3 \text{ m} \cdot \text{s}^{-1}$, the error in $T \leq 10 \%$.

A.3 Gradient between incoming and outgoing air

The gradient between incoming and outgoing air is expressed as:

$$\Delta T_{\text{air}} = \frac{P}{C_p G}$$