IEC 60068-3-1

Edition 3.0 2023-06
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

IEC 60068-3-1:2023-06 RLV(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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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;
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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

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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.

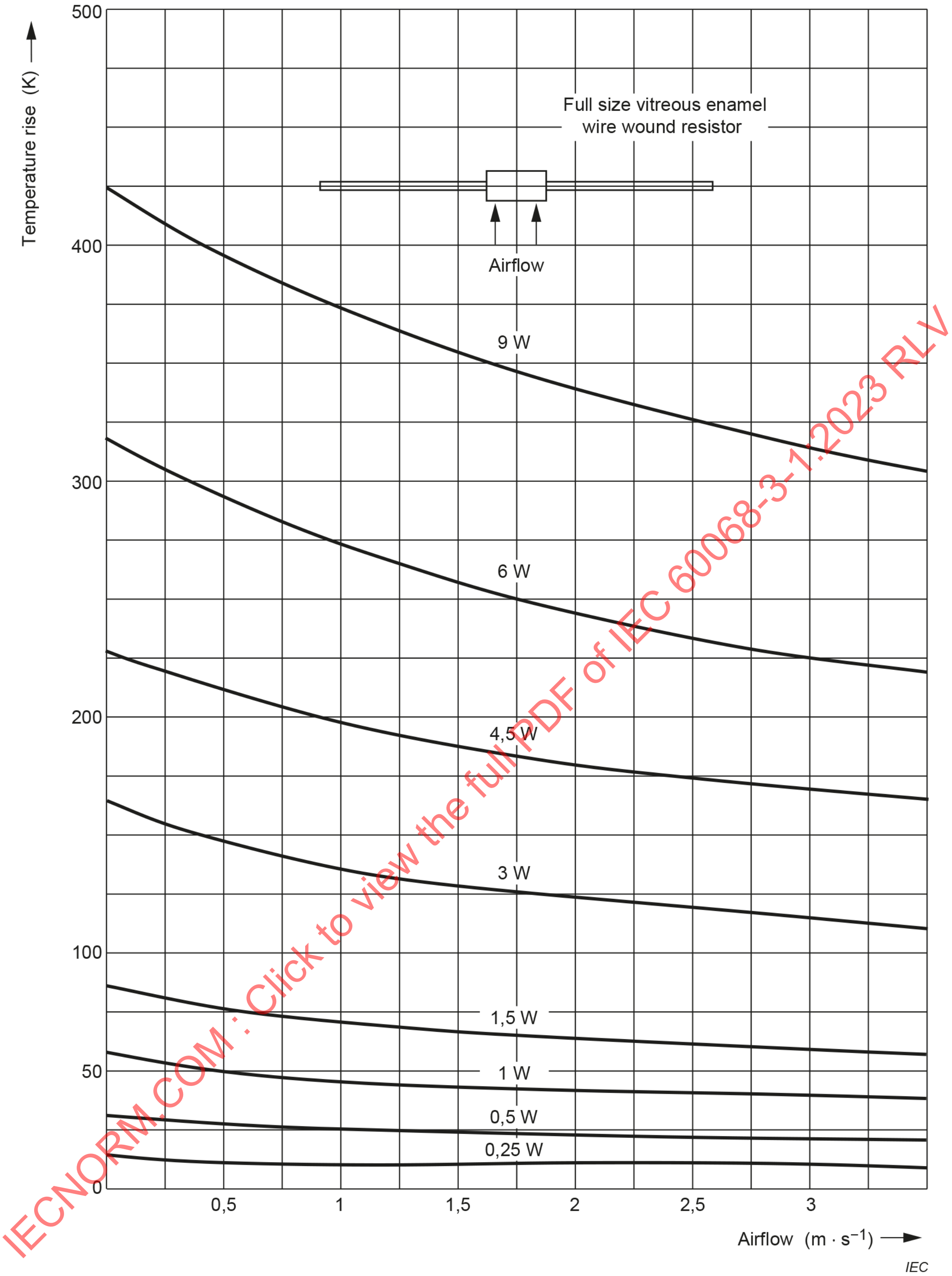

Figure 1 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Radial airflow

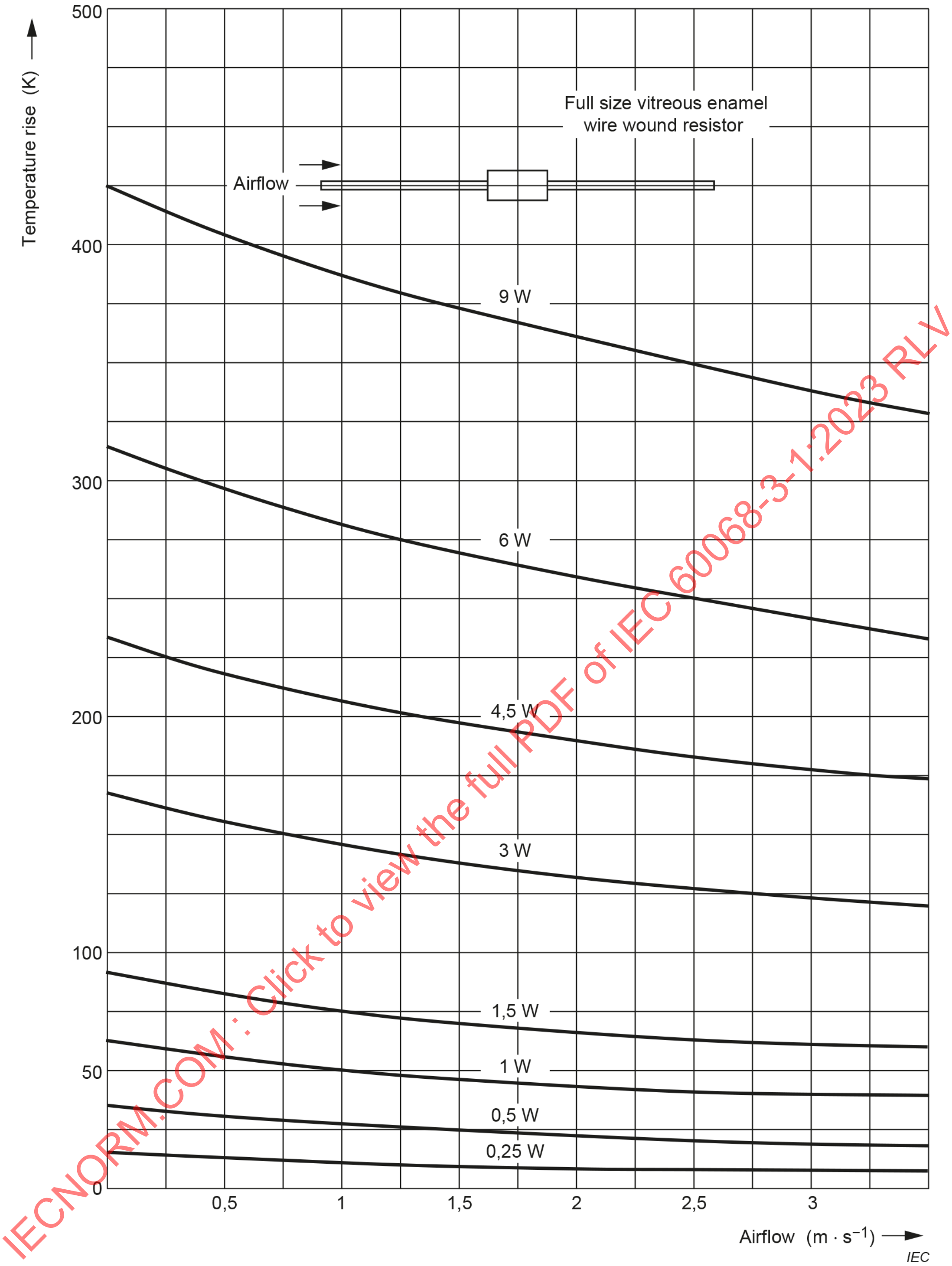

Figure 2 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Axial airflow

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.

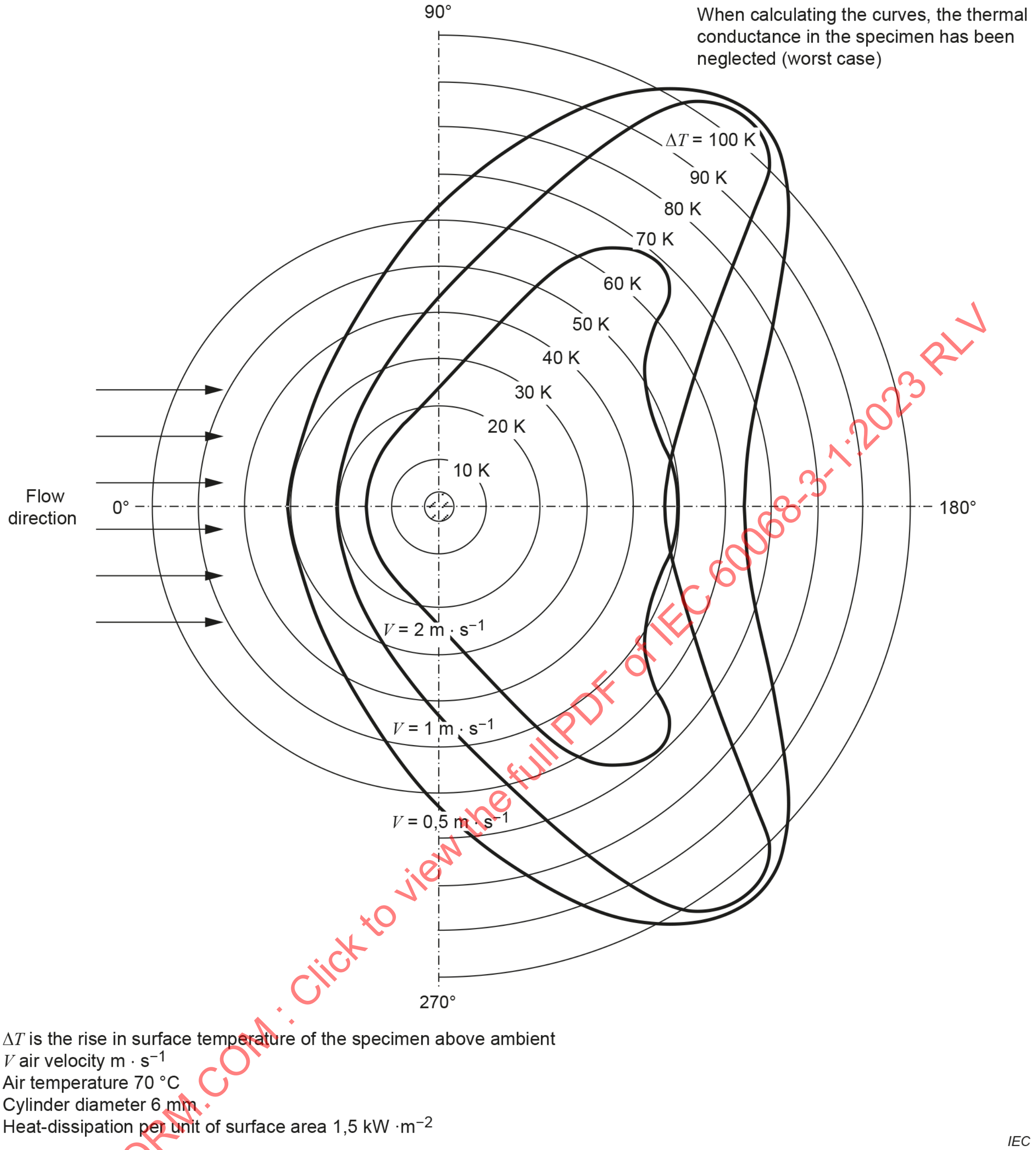

Figure 3 – Temperature distribution on a cylinder with homogeneous heat generation in airflow of velocities (0,5, 1 and 2) m · s^{-1}

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 ($m \cdot s^{-1}$);

$\lambda(V)$ is the heat transfer coefficient ($W \cdot m^{-2} \cdot K^{-1}$);

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 ($kg \cdot s^{-1}$);

C_p is the specific heat of air at constant pressure (1 000 $J \cdot kg^{-1} \cdot K^{-1}$);

γ is the density of air (1,29 $kg \cdot m^{-3}$);

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

$\lambda(V) = a + bV$

$a \cong 10$

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

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 $m \cdot s^{-1}$, $b \cong 8$.

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

A.3 Gradient between incoming and outgoing air

The gradient between incoming and outgoing air is expressed as:

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

Substituting numerical values for a cubic chamber of 0,5 m side length with an airflow of 0,3 m · s^{-1} and a power dissipation within the chamber of 100 W gives:

$$S = 0{,}25\ \text{m}^2$$

$$\Delta T_{air} = \frac{100}{1000 \times 0{,}25 \times 0{,}3 \times 1{,}29}\ \text{K} \cong 1\ \text{K}$$

$$\Delta T_{air} = \frac{100\ \text{W}}{1000\ \frac{\text{J}}{\text{kg} \cdot \text{K}} \times 0{,}25\ \text{m}^2 \times 0{,}3\ \frac{\text{m}}{\text{s}} \times 1{,}29\ \frac{\text{kg}}{\text{m}^3}} \cong 1\ \text{K}$$

Up to 100 W dissipation, there is little concern. At 1 kW, a chamber with a larger volume or higher air exchange should be considered.

Bibliography

IEC 60068-1:2013, *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*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

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

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

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Partie 3-1: Documentation d'accompagnement et recommandations – Essais de froid et de chaleur sèche

IEC 60068-3-1:2023-06(en-fr)

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ENVIRONMENTAL TESTING –

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

1 Scope

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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.]

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non 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 equal or less than 5 K above the ambient temperature of the surrounding atmosphere after thermal stability has been reached

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free-air conditions
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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).

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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.

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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.

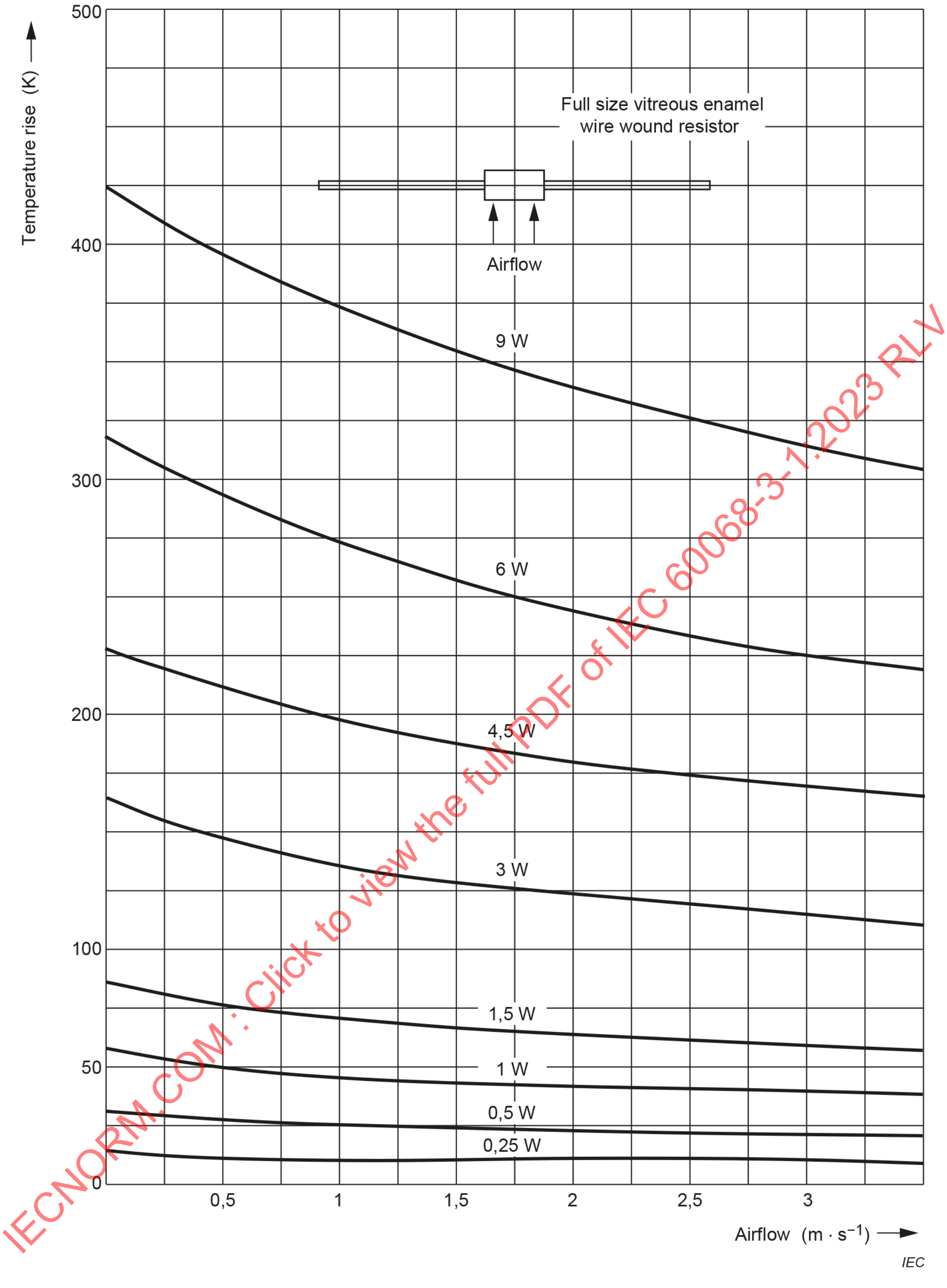

Figure 1 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Radial airflow

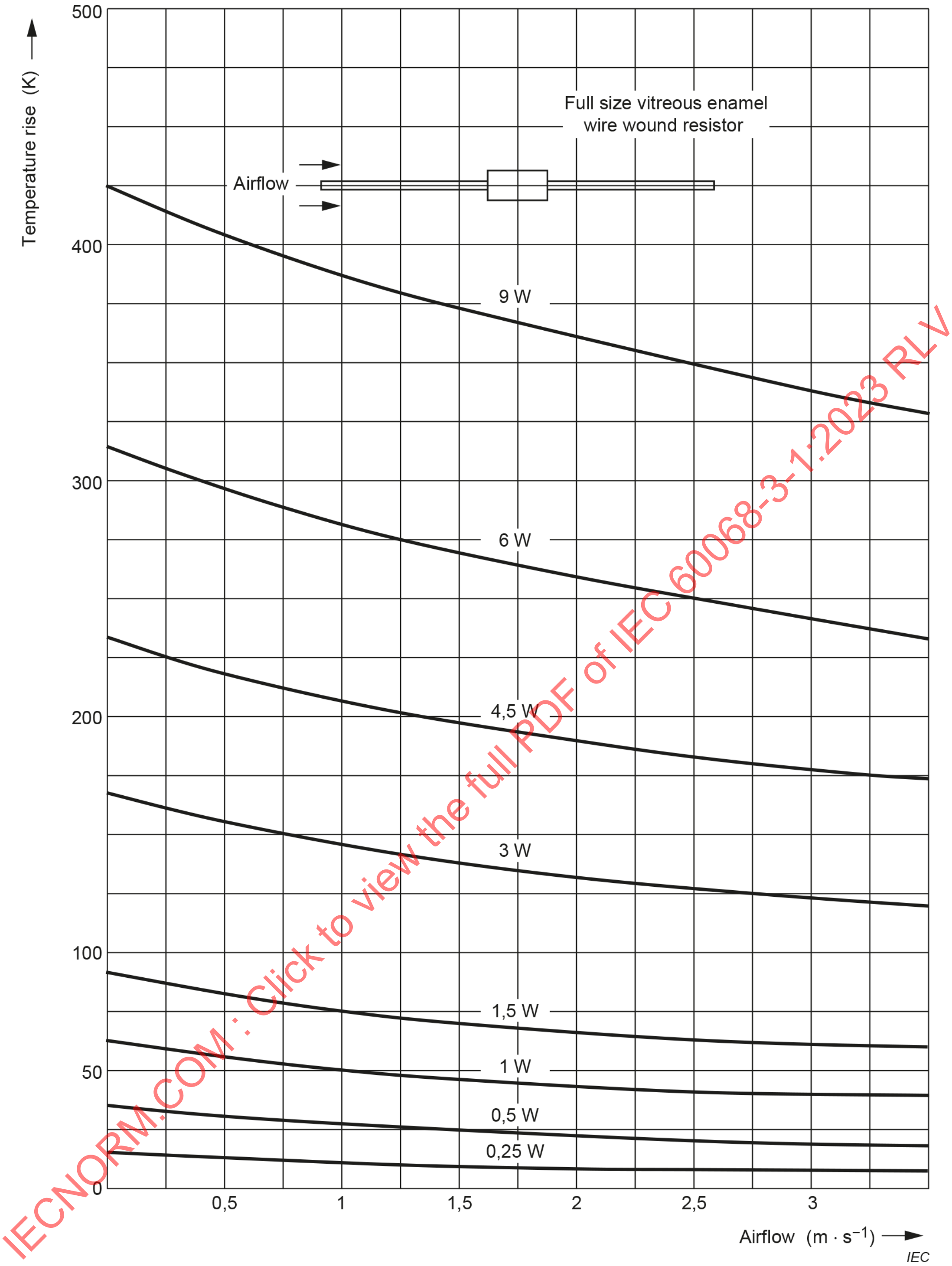

Figure 2 – Experimental data on the effect of airflow on the surface temperature of a wire-wound resistor – Axial airflow

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.

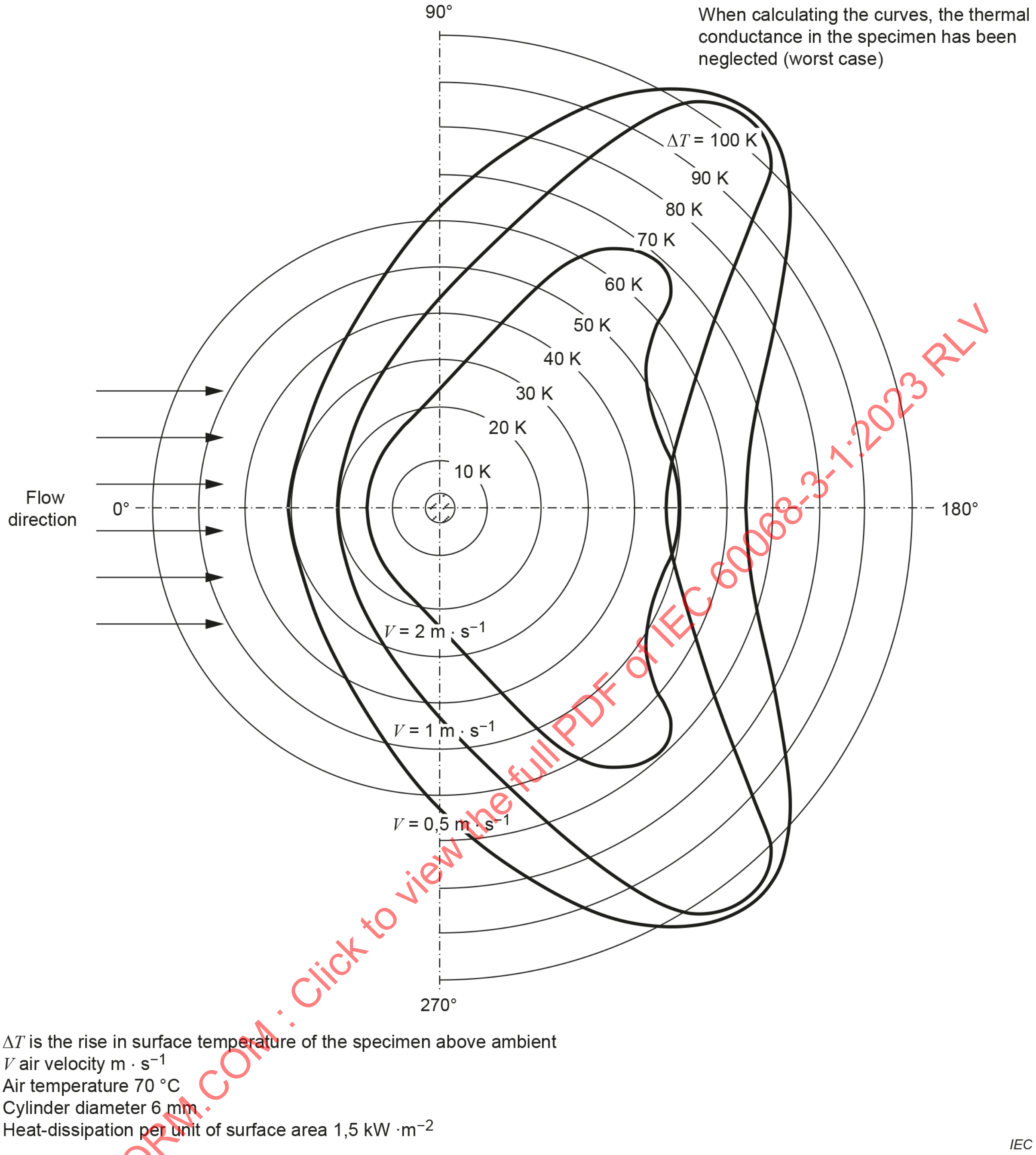

Figure 3 – Temperature distribution on a cylinder with homogeneous heat generation in airflow of velocities (0,5, 1 and 2) m · s^{-1}

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 should define the thermal characteristics of the mounting and these characteristics should be reproduced when the test is made.

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 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 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 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 ($m \cdot s^{-1}$);
$\lambda(V)$	is the heat transfer coefficient ($W \cdot m^{-2} \cdot K^{-1}$);
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 ($kg \cdot s^{-1}$);
C_p	is the specific heat of air at constant pressure (1 000 $J \cdot kg^{-1} \cdot K^{-1}$);
γ	is the density of air (1,29 $kg \cdot m^{-3}$);
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

$\lambda(V) = a + bV$

$a \cong 10$

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

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 $m \cdot s^{-1}$, $b \cong 8$.

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

A.3 Gradient between incoming and outgoing air

The gradient between incoming and outgoing air is expressed as:

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

Substituting numerical values for a cubic chamber of 0,5 m side length with an airflow of 0,3 m · s^{-1} and a power dissipation within the chamber of 100 W gives:

$$S = 0{,}25\ \text{m}^2$$

$$\Delta T_{\text{air}} = \frac{100\ \text{W}}{1000\ \frac{\text{J}}{\text{kg}\cdot\text{K}} \times 0{,}25\ \text{m}^2 \times 0{,}3\ \frac{\text{m}}{\text{s}} \times 1{,}29\ \frac{\text{kg}}{\text{m}^3}} \cong 1\ \text{K}$$

Up to 100 W dissipation, there is little concern. At 1 kW, a chamber with a larger volume or higher air exchange should be considered.

Bibliography

IEC 60068-1:2013, *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*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

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

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ESSAIS D'ENVIRONNEMENT –

Partie 3-1: Documentation d'accompagnement et recommandations – Essais de froid et de chaleur sèche

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Cette troisième édition annule et remplace la deuxième édition parue en 2011. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) les informations relatives à la température des spécimens ont été révisées;
b) les informations relatives aux essais sur plusieurs spécimens ont été révisées;
c) l'effet de la masse volumique de l'air a été ajouté;

d) une recommandation concernant les actions correctives relatives aux rayonnements IR a été ajoutée;

e) les exigences relatives au montage et aux supports des spécimens ont été révisées.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
104/986/FDIS	104/1002/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 60068, publiées sous le titre général *Essais d'environnement*, se trouve sur le site web de l'IEC.

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ESSAIS D'ENVIRONNEMENT –

Partie 3-1: Documentation d'accompagnement et recommandations – Essais de froid et de chaleur sèche

1 Domaine d'application

La présente partie de l'IEC 60068 fournit des recommandations concernant l'exécution des essais de froid et de chaleur sèche.

2 Références normatives

Le présent document ne contient aucune référence normative.

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse https://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse https://www.iso.org/obp

3.1
spécimen dissipant de la chaleur
spécimen pour lequel la température au point le plus chaud de sa surface, mesurée dans des conditions d'air libre et sous la pression atmosphérique spécifiée dans l'IEC 60068-1, dépasse la température ambiante de l'atmosphère environnante de plus de 5 K lorsque la stabilité thermique a été atteinte

[SOURCE: IEC 60068-1:2013, 3.6, modifié – La définition a été légèrement adaptée et la Note 1 à l'article a été supprimée.]

3.2
spécimen ne dissipant pas de chaleur
spécimen pour lequel la température au point le plus chaud de sa surface, mesurée dans des conditions d'air libre et sous la pression atmosphérique spécifiée dans l'IEC 60068-1, dépasse la température ambiante de l'atmosphère environnante de moins de 5 K lorsque la stabilité thermique a été atteinte

3.3
conditions d'air libre
conditions existant dans un espace infini où le mouvement de l'air n'est affecté que par le spécimen dissipant de la chaleur

Note 1 à l'article: Les conditions d'air libre peuvent s'appliquer à l'environnement de laboratoire. Il convient d'indiquer les conditions de mesurage dans le rapport d'essai (sauf spécification contraire).

[SOURCE: IEC 60068-1:2013, 3.7, modifié – Dans le terme, "calme" a été remplacé par "libre"; dans la définition, "lui-même" a été supprimé et la Note 1 à l'article a été ajoutée.]

4 Choix des procédures d'essai

4.1 Contexte général

4.1.1 Généralités

Les performances du spécimen peuvent être influencées ou limitées par les températures de fonctionnement du spécimen. Le niveau d'influence peut être affecté par les gradients d'essai présents dans le système d'essai (chambre climatique ou environnementale) et par les températures internes du spécimen lui-même. Pour déterminer le niveau d'influence qui existe et s'assurer que le spécimen est conçu de façon appropriée, des essais de froid et/ou de chaleur sèche sont réalisés.

4.1.2 Température ambiante

Il convient de connaître les valeurs de température ambiante maximale et minimale auxquelles le spécimen est destiné à fonctionner. Les valeurs préférentielles pour les essais sont fournies dans l'IEC 60068-2-1 et/ou l'IEC 60068-2-2.

Des difficultés peuvent apparaître sous l'effet de la transmission thermique qui provoque des variations de température dans la zone entourant le spécimen. Par conséquent, il convient de prendre en compte l'effet de la transmission thermique à la température ambiante de l'atmosphère environnante. Il convient de prendre également en compte la circulation d'air liée à l'espacement entre les spécimens pendant la réalisation d'un essai.

4.1.3 Températures du spécimen

Les performances du spécimen peuvent être altérées par sa propre température dans le cas de spécimens dissipant de la chaleur. C'est pourquoi, lors du contrôle de l'environnement d'essai, il peut être nécessaire de mesurer la température en différents points à l'intérieur et à l'extérieur du spécimen d'essai.

La variation de la température en un point sur la surface d'un spécimen suit approximativement une loi exponentielle. À l'intérieur des grands spécimens, l'égalisation de la température peut être atteinte avec un délai significatif.

En cas de doute concernant la manière dont la variation de température est reflétée par le spécimen, il est recommandé de surveiller la température des spécimens en un ou plusieurs points représentatifs.

NOTE Pour plus d'informations concernant l'influence des températures d'essai sur les spécimens, l'IEC 60068-2-14 ou l'IEC 60068-3-11 peut être pertinente.

4.1.4 Spécimens ne dissipant pas de chaleur

Si la température ambiante est uniforme et constante, et qu'il n'y a aucune production de chaleur à l'intérieur du spécimen, la chaleur circule depuis l'atmosphère ambiante dans le spécimen si la température de l'atmosphère ambiante est plus élevée. Inversement, la chaleur circule du spécimen dans l'atmosphère ambiante si la température du spécimen est plus élevée. Cette transmission thermique se poursuit tant que le spécimen n'a pas complètement atteint l'équilibre thermique avec l'atmosphère environnante. La transmission thermique cesse alors à partir de cet instant et ne se reproduit que si la température ambiante varie.

4.1.5 Spécimens dissipant de la chaleur

S'il y a production de chaleur à l'intérieur du spécimen, la température du spécimen s'élève jusqu'à un point de stabilisation supérieur à la température ambiante. Si une température stable est atteinte, la chaleur se dégage alors en continu du spécimen par convection, rayonnement et conduction vers l'atmosphère, ce qui refroidit le spécimen.

Si plusieurs spécimens sont soumis à un essai de chaleur sèche dans la même chambre, il est nécessaire de s'assurer que tous les spécimens sont placés à la même température ambiante et dans des conditions de montage identiques. Il peut être nécessaire de distinguer les essais effectués sur un seul spécimen et sur plusieurs spécimens lorsque l'essai de froid est effectué.

NOTE Si plusieurs spécimens sont soumis à l'essai dans la même chambre d'essai, la circulation uniforme de l'air pénétrant peut être perturbée.

4.2 Mécanismes de transmission thermique

4.2.1 Convection

La transmission thermique par convection est un facteur important lors des essais des spécimens dissipant de la chaleur. Le coefficient de transmission thermique de la surface du spécimen d'essai à l'air ambiant dépend de la vitesse et la masse volumique de l'air environnant. Plus la vitesse de l'air est grande, plus la transmission thermique est efficace. Ainsi, pour une température de l'air ambiant donnée, la température de la surface du spécimen d'essai est d'autant plus faible que la vitesse de l'air est plus élevée. Cet effet est mis en évidence par la Figure 1 et la Figure 2.

La masse volumique de l'air a également une influence significative sur la transmission thermique. L'air froid est plus dense que l'air chaud. Par conséquent, l'air chaud provoque une transmission thermique plus faible que l'air froid.

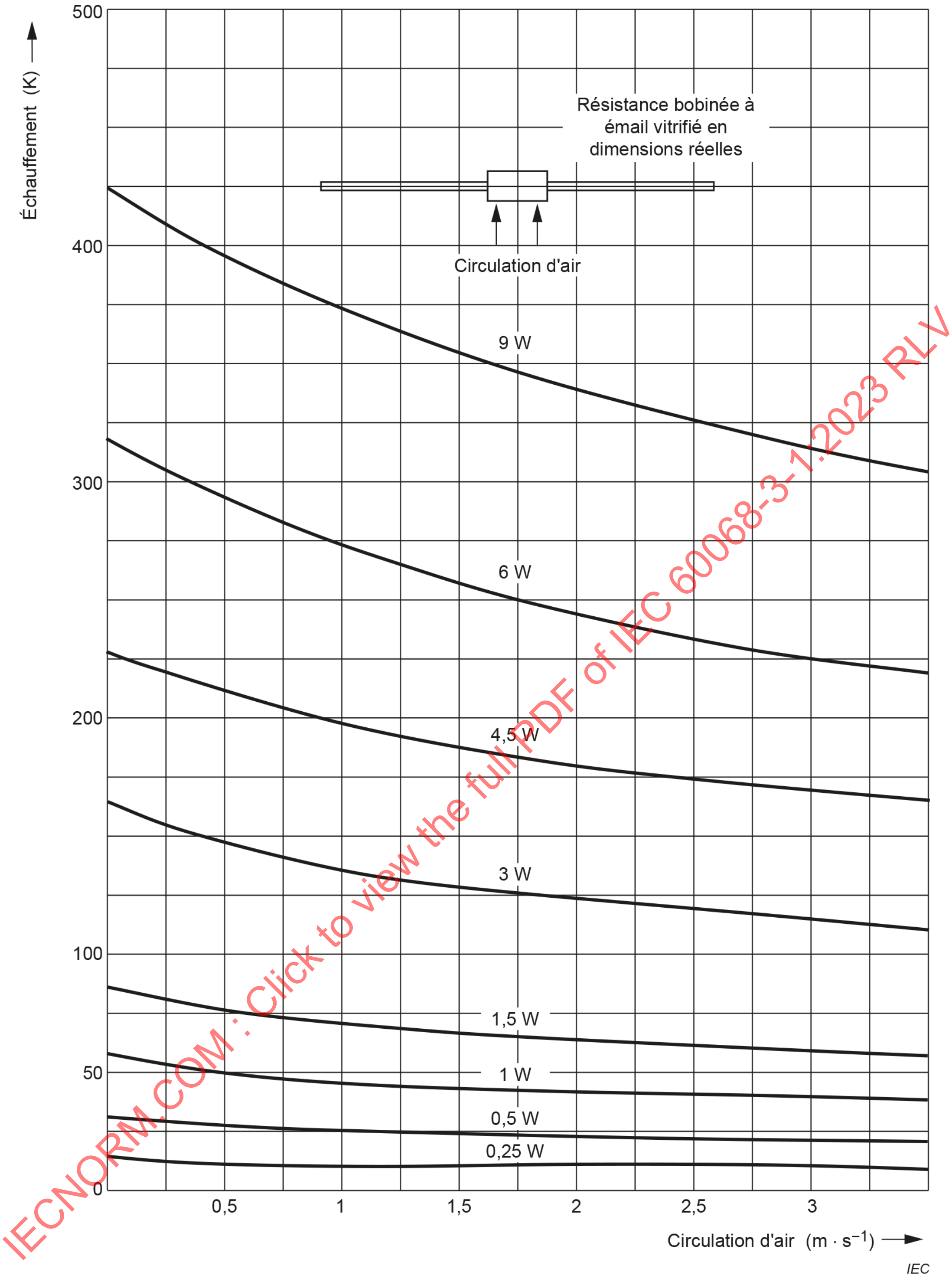

Figure 1 – Données expérimentales concernant l'effet de la circulation d'air sur la température de surface d'une résistance bobinée – Circulation d'air selon une direction radiale