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Environmental testing - Part 2-2: Tests - Test B: Dry heat

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Environmental testing - Part 2-2: Tests - Test B: Dry heat

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IEC 60068-2-2 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2007. This edition constitutes a technical revision.

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

a) revision of the introduction and scope;
b) inclusion of new figures and symbols for clarification purposes;
c) clarification of the test procedure for ascertaining high or low air velocity in the test chamber;
d) clarification of the requirements for measuring points around, on or in specimens;
e) reintroduction of the nomogram procedure for the correction of the conditioning temperature when testing with high air velocity (Test Bd and Test Be);

f) revision of the temperature tolerances of the test;

g) revision of standardized requirements for the relevant specification and test report;

h) inclusion of the advantages and disadvantages of the testing procedures.

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

Draft	Report on voting
104/1108/FDIS	104/1128/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 the parts of the IEC 60068 series, 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– withdrawn, or

– revised.

INTRODUCTION

The working ranges and performance of equipment and machinery can be significantly affected or limited by ambient temperatures. The degree of this influence can depend on temperature distributions of the environment as well as temperatures on components of the device itself. In order to determine the existing degree of influence and to ensure that the device is suitably designed for its ambient conditions, tests are carried out with cold (IEC 60068-2-1) or dry heat, or both. During the test detailed in this document, it will be taken into account whether the tested device itself emits heat or not.

Reducing the air flow within the test chamber can be required to reduce the air velocity at heat-dissipating specimens. This can be achieved by using air baffles or adjusting the air flow of the test chamber. If the reduction of air velocity is not practical or possible due to the required test conditions, this document provides an alternative test procedure without the need for adjustable air flow as well as guidance on selecting the applicable test procedure.

1 Scope

This part of IEC 60068 specifies dry heat temperature tests that are applicable to non-heat-dissipating and heat-dissipating specimens, to determine the ability of components, equipment or other articles to be used, transported or stored at high temperature.

This document is applicable to energized as well as non-energized specimens that normally achieve temperature stability during the test. The specimens can be subject to test in packed condition (to simulate transportation and storage) or in unpacked condition (to simulate use).

This document does not specify tests to determine the impact of temperature changes on specimens.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-5-2, *Environmental testing - Part 5-2: Guide to drafting of test methods - Terms and definitions*

IEC 60721 (all parts), *Classification of environmental conditions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1, IEC 60068-5-2 and the following apply.

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

– IEC Electropedia: available at https://www.electropedia.org/
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3.1
low air velocity
velocity of conditioning airflow within a working space which is sufficient to maintain conditions but low enough so that the temperature at the relevant point or relevant points on the test specimen is not reduced by more than 5 K by the influence of the circulation of the air

Note 1 to entry: The relevant points to be considered are determined by the relevant test specification.

3.2
high air velocity
velocity of conditioning airflow within a working space, which, in order to maintain conditions, also reduces the temperature at the relevant point or relevant points on the test specimen by more than 5 K by the influence of the circulation of the air

4 Symbols

T_B high conditioning temperature [°C]

$T_{B'}$ corrected high conditioning temperature (nomogram procedure) [°C]

T_{STD} temperature of standard atmospheric conditions for measurement and tests (15 °C to 35 °C) [°C]

T_{Ca} measured ambient temperature in the vicinity of the specimen, either in the test chamber or the laboratory air, without forced convection (see 5.2) [°C]

T_{Cb} measured test chamber temperature with forced convection (see 5.2) [°C]

T_S temperature of the energized specimen at the specified conditioning temperature [°C]

T_{Sa} temperature of the energized specimen at the temperature of standard atmospheric conditions without forced convection (see 5.2) [°C]

T_{Sb} temperature of the energized specimen at the temperature of standard atmospheric conditions with forced convection (see 5.2) [°C]

ΔT_S temperature difference between the energized specimen and the air [K]

$\Delta T_{Sa/b}$ temperature difference between the energized specimen without forced convection (T_{Sa}) and with forced convection (T_{Sb}) at the temperature of standard atmospheric conditions [K]

$\mathrm{d}T_R$ temperature change rate [K/min]

t_s stabilization time of specimen temperature before exposure to the high conditioning temperature [min or h]

t_{s0} stabilization time of specimen temperature after energizing [min or h]

t_1 exposure time of the specimen to the high conditioning temperature [h]

5 Application of tests for non-heat-dissipating specimens versus tests for heat-dissipating specimens

5.1 General

This test is subdivided as follows:

– Test Bb: Dry heat for non-heat-dissipating specimens;

– Test Bd: Dry heat for heat-dissipating specimens that are energized after initial temperature stabilization;

– Test Be: Dry heat for heat-dissipating specimens that are energized throughout the test.

A specimen, while energized, is considered to be heat-dissipating only if the hottest point on its surface or any other relevant point, measured in free air conditions (i.e. low air velocity circulation), is more than 5 K above the ambient temperature of the surrounding atmosphere after temperature stability has been reached (see IEC 60068-1).

NOTE 1 In some cases, for example for test specimens with air-permeable housings, the relevant measuring points can be located inside the external housing.

Tests of heat-dissipating and non-heat-dissipating specimens generally differ in the air velocity applied. Non-heat-dissipating specimens are typically tested at high air velocity to reduce the time required to reach temperature stability. Heat-dissipating specimens are generally tested at low air velocity to allow for the formation of local hotspots similar to those that would appear in installed applications. Annex A gives an overview of the relevant test conditions and shows the relationship of suffixes between Test A: Cold and Test B: Dry heat.

It is possible that testing with low air velocity does not apply to heat-dissipating specimens with an external housing and built-in fan, provided that the representative measuring point is located at a point inside the external housing which is not affected by external air movement. Ensure that the induced air movement does not interfere with the operation of the built-in fan, if not specified otherwise.

NOTE 2 The induced air movement can have an influence on the operation of a built-in fan if both air movements act either in the same or opposite direction.

Where it is not feasible to test heat-dissipating specimens with low air velocity, for example due to the required test conditions, Annex B gives an alternative procedure for testing with high air velocity.

The relevant specification shall state which test procedure shall be applied. The advantages and disadvantages of both test procedures should be considered when specifying the intended test. For more information on these advantages and disadvantages, see Annex C.

When the relevant specification calls for a storage or transportation test or does not specify an applied load during the test, Test Bb applies.

5.2 Ascertaining high or low air velocity in the test chamber

To ascertain, whether high or low air velocity prevails in the test chamber, the cooling effect of the air movement on the specimen shall be determined. Therefore, the specimen's temperature shall be measured with and without forced convection by the test chamber's fan. Both temperatures shall be compared in accordance with the following procedure. It is recommended to ascertain the prevailing air velocity in the test chamber for every specimen, since the occurring cooling effect can vary for different specimens.

Under standard atmospheric conditions for measurements and tests (see IEC 60068-1) with an air velocity < 0,2 m/s, achieved without forced convection, the heat-dissipating specimen shall be switched on or electrically loaded as specified for the high temperature at which the test is to be carried out.

When temperature stability of the specimen has been reached, the temperature of a representative point around or on the specimen and the ambient temperature T_{Ca} shall be measured using a suitable monitoring device. Either the hottest point or any point of particular interest on the specimen can be used as representative point for measuring the temperature of the energized specimen T_{Sa} without forced convection.

NOTE 1 To determine the representative point, an infrared camera can be helpful.

The temperature reached at each point shall then be noted. This measurement may be done in an open test chamber (e.g. with an opened door or a lifted test space enclosure, if applicable) or outside of the test chamber to prevent an improper temperature rise of the surrounding air.

NOTE 2 The operation of a heat-dissipating specimen in a closed and switched-off test chamber leads to a temperature rise within the test space. In a small test chamber or with a large heat load, the temperature rise can influence the measurement result.

NOTE 3 The temperature T_{Ca} is the temperature in the vicinity of the specimen during the measurement without forced convection. It can be the temperature in the test chamber or the temperature of the laboratory air, depending on where the test was done.

The specimen is then introduced into the test chamber, if applicable, and test chamber is switched on. The temperature is set to the previously recorded temperature T_{Ca}.

Once temperature stability of the energized specimen has been achieved, the temperature of the representative point and the test chamber temperature T_{Cb} shall be measured. The temperatures T_{Sa} and T_{Sb} shall be measured at the same point around or on the specimen.

NOTE 4 The temperature T_{Cb} is the test chamber temperature during the test with forced convection. It can vary marginally from temperature T_{Ca}.

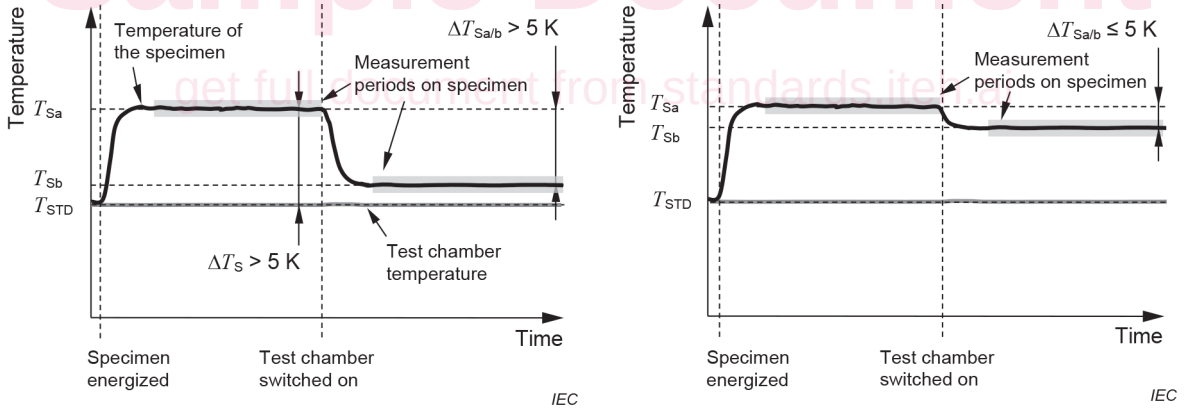
The following applies:

$$\Delta T_{Sa/b} = T_{Sa} - T_{Sb} \quad (1)$$

If the temperature difference $\Delta T_{Sa/b}$ between the temperature of the specimen with and without forced convection is more than 5 K (or a value stated by the relevant specification) this value shall be noted in the test report and the test chamber is considered to have high air velocity. The specimen is then switched off and any operational loading conditions removed.

For some specimens, for example large specimens or specimens with a complex geometry, more than one representative point around or on the specimen can be used for measuring the temperature of the specimen. For some specimens, for example specimens with air-permeable housings, the relevant measuring point or points can be located inside the external housing. The relevant specification shall state the number and location of the measuring points.

Figure 1 shows a comparison of examples of temperature profiles in test chambers with high and low air velocity.



a) temperature profile of an energized heat-dissipating specimen in a test chamber with high air velocity

b) temperature profile of an energized heat-dissipating specimen in a test chamber with low air velocity

Figure 1 – Examples of temperature profiles of energized heat-dissipating specimens in test chambers with a) high air velocity and b) low air velocity

5.3 Temperature monitoring

The air temperature in the test chamber shall be measured by temperature sensors located at such a distance from the specimen that the effect of the dissipation is negligible. Suitable precautions shall be taken to avoid heat radiation affecting these measurements.

5.4 Packaging

Packaging shall be removed unless the relevant specification requires it to remain in place or heating elements are incorporated in the package. For storage and transportation tests, the specimen may be tested with its packaging in place.

NOTE Packaged specimens are expected to stabilize at chamber temperature after a certain exposure time.

5.5 Background

To facilitate the choice of test method, a diagrammatic representation of the various procedures is given in Figure 2.

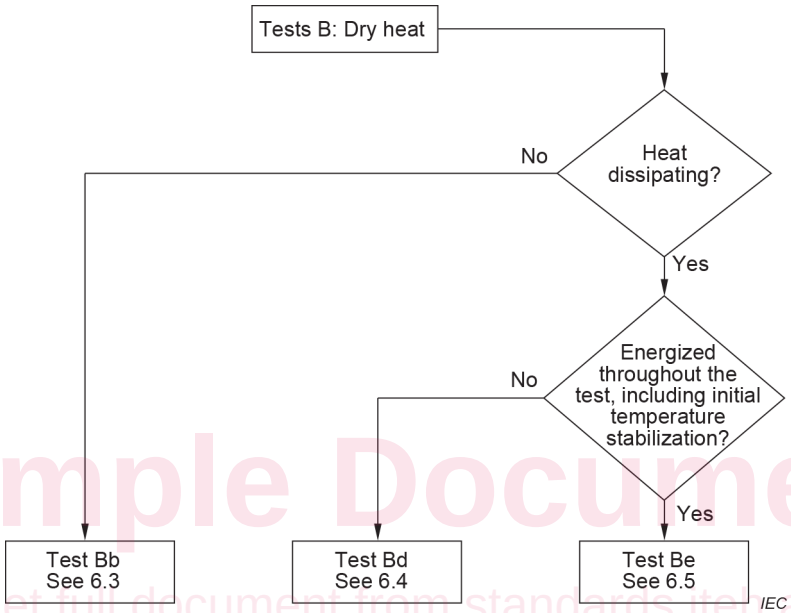


Figure 2 – Block diagram of the test procedures and applicable selection criteria of Test B: Dry heat

6 Test descriptions

6.1 General

For each test, the test chamber shall be at the temperature of standard atmospheric condition T_{STD}, 15 °C to 35 °C, when the test specimens are introduced. The temperature shall then be gradually raised to the high conditioning temperature T_B appropriate to the degree of severity, as specified in the relevant specification.

NOTE 1 The gradual temperature change prevents detrimental effects on the specimen caused by thermal stress due to the change of temperature. For more information on thermal stress caused by temperature change, see IEC 60068-2-14.

The temperature change rate dT_R within the chamber shall not exceed 1 K/min, averaged over a period of not more than 5 min. The relevant specification shall define the functioning of the specimen under test. Further requirements for each test are noted in 6.3, 6.4 and 6.5.

Any cooling or heating devices of the specimen shall be in accordance with the requirement in the relevant specification.

NOTE 2 IEC 60068-3-1 provides general guidance for the performance of Tests A and B. IEC 60068-3-6 provides guidance for the confirmation of performance of test chambers without specimen. IEC 60068-3-7 provides further information on testing with test specimens within the test chamber.

6.2 Severities

6.2.1 General

The severities, as indicated by the high conditioning temperature T_B and the exposure time t_1, shall be specified by the relevant specification. If these values are not given in the relevant specification, they shall be:

a) chosen from the values given in Table 1 (see 6.2.2) and Table 2 (see 6.2.3); or

b) derived from known environments, if these give significantly different values; or

c) derived from other known sources of relevant data (for example the IEC 60721 series or field data from the specimen).

6.2.2 High conditioning temperature T_B

Table 1 – Preferred values for the high conditioning temperature T_B

+1 000 °C	+800 °C	+630 °C	+500 °C	+400 °C
+315 °C	+250 °C	+200 °C	+175 °C	+155 °C
+125 °C	+100 °C	+85 °C	+70 °C	+65 °C
+60 °C	+55 °C	+50 °C	+45 °C	+40 °C
+35 °C	+30 °C			

6.2.3 Exposure time t_1

Table 2 – Preferred values for the exposure time t_1

2 h	16 h	72 h	96 h
168 h	240 h	336 h	1 000 h

NOTE For further information on the test duration, IEC TR 60721-4 series can be helpful.

6.3 Test Bb: Dry heat for non-heat-dissipating specimens

Test Bb is intended for non-heat-dissipating specimens which are subjected to the high conditioning temperature T_B with high air velocity for a time long enough for the specimen to achieve temperature stability and maintain the test conditions for the specified exposure time t_1.

The specimen is introduced into the test chamber, which is at the temperature of standard atmospheric condition for measurement and tests T_{STD}, 15 °C to 35 °C. The temperature is then adjusted to the high conditioning temperature T_B appropriate to the degree of severity as specified in the relevant specification. After temperature stability of the test specimen has been reached, the specimen stays exposed to the high conditioning temperature T_B for the specified exposure time t_1 (see Figure 3). A representative point (or points) on or inside the specimen may be used for this measurement.

NOTE 1 For further information on thermal stability, see IEC 60068-1.

If a measuring point on or inside the specimen can damage the specimen, a representative point (or points) around the specimen may be used instead.

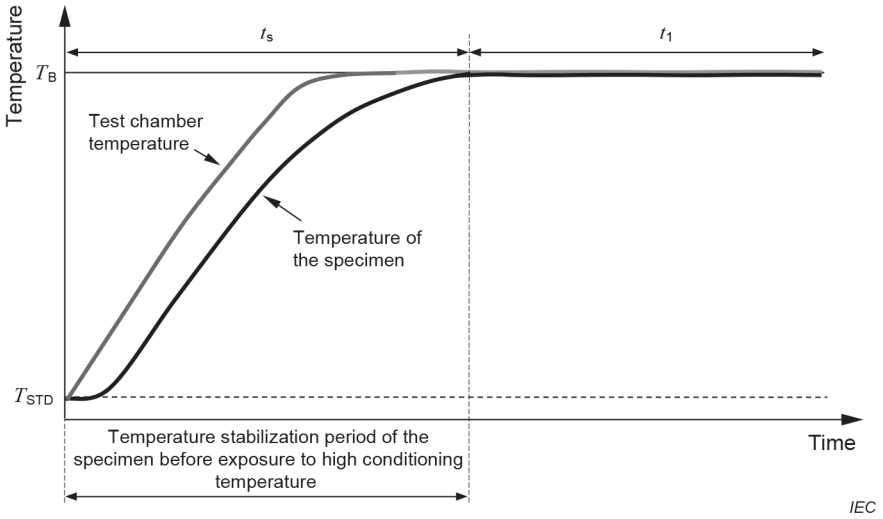


Figure 3 – Test Bb: Dry heat for non-heat-dissipating and non-operating specimens

Specimens under test are normally in non-operating conditions. High air velocity circulation is normally used for this test.

NOTE 2 In the case of a non-heat-dissipating specimen in Test Bb, high air velocity in the test chamber can be assumed, when no measures are taken to disturb the air flow (e.g. by bulkheading installations, like perforated plates or air baffles, or the reduction of the overall air flow within the test chamber).

Specimens that are required to be operational but do not meet the requirements of being heat dissipating shall be energized after temperature stabilization at the high conditioning temperature T_B is achieved (see Figure 4), if not specified otherwise. A functional test shall be performed as specified in the relevant specification, if applicable. A further stabilization time of the specimen temperature (t_{s0}) can be necessary. The specimen shall then be exposed to the high conditioning temperature T_B for the specified exposure time t_1.

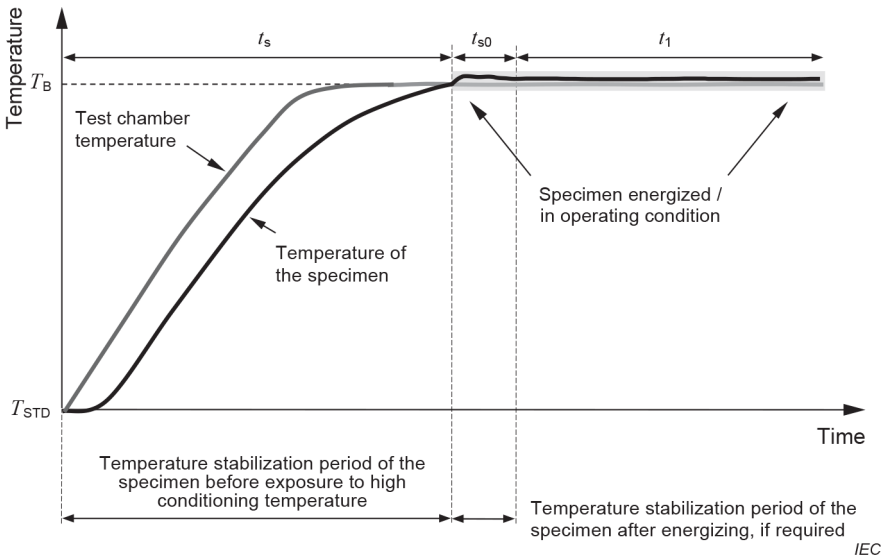


Figure 4 – Test Bb: Dry heat for non-heat-dissipating, operating specimens

6.4 Test Bd: Dry heat for heat-dissipating specimens that are energized after initial temperature stabilization

Test Bd is intended for heat-dissipating specimens which are subjected to the high conditioning temperature T_B with low air velocity for a time long enough for the specimens to achieve temperature stability and maintain the test conditions for the specified exposure time t_1. The specimens are energized after the initial temperature stabilization.

The specimen is introduced into the test chamber, which is at the temperature of standard atmospheric condition for measurement and tests T_{STD}, 15 °C to 35 °C. The temperature is then adjusted to the high conditioning temperature T_B appropriate to the degree of severity as specified in the relevant specification.

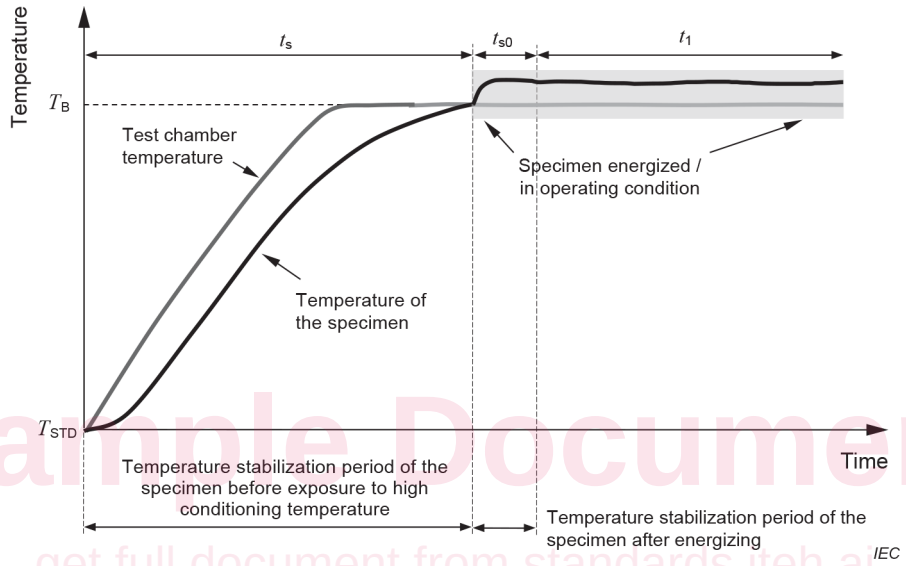


Figure 5 – Test Bd: Dry heat for heat-dissipating specimens that are energized after initial temperature stabilization

After the temperature stabilization period of the specimen t_s before exposure to the high conditioning temperature, the specimen is energized, stabilized again and then exposed to the high conditioning temperature T_B for the specified exposure time t_1. A representative point (or points) on or inside the specimen may be used for this measurement. The specimen shall remain in the operating condition as specified by the relevant specification.

NOTE 1 For further information on thermal stability, see IEC 60068-1.

If a measuring point on or inside the specimen can damage the specimen, a representative point (or points) around the specimen may be used instead.

Low air velocity circulation is normally used for this test. If necessary, a test is performed to determine if the test chamber fulfils the requirements of low air velocity (see 5.2). If low air velocity is not suitable for this test, the test procedure described in Annex B may be used.

NOTE 2 For further information on testing with low air velocity, see Annex C.