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NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA

ICS 19.040
K 04

GB/T 2423.63-2019

**Environmental testing - Part 2: Test methods -
Test: combined temperature (cold and heat)/low air
pressure/vibration (mixed mode)**

环境试验 第2部分：试验方法

试验：温度（低温、高温）/低气压/振动（混合模式）综合

Issued on: May 10, 2019

Implemented on: December 01, 2019

Issued by: State Administration for Market Regulation;

Standardization Administration of the PRC.

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Environmental testing - Part 2: Test methods - Test: combined temperature (cold and heat)/low air pressure/vibration (mixed mode)

1 Scope

This Part of GB/T 2423 specifies the basic requirements, severities, test procedure and other technical details for the combined test of temperature (cold and heat)/low air pressure/vibration (mixed mode).

This Part is suitable for determining the product's adaptability for storage, transportation and use under the combined effects of temperature (cold and heat)/low air pressure/vibration (mixed mode). Combined tests with temperature changes may refer to this Part.

2 Normative references

The following documents are indispensable for the application of this document. For the dated references, only the editions with the dates indicated are applicable to this document. For the undated references, the latest edition (including all the amendments) are applicable to this document.

GB/T 2422 Environmental testing - Guide to drafting of test methods - Terms and definitions

GB/T 2423.1 Environmental testing - Part 2: Test methods - Tests A: Cold

GB/T 2423.2 Environmental testing - Part 2: Test methods - Tests B: Dry heat

GB/T 2423.10 Environmental testing - Part 2: Test methods - Test Fc: Vibration (sinusoidal)

GB/T 2423.21 Environmental testing - Part 2: Test methods - Test M: Low air pressure

GB/T 2423.22 Environmental testing - Part 2: Tests methods - Test N: Change of temperature

GB/T 2423.26 Environmental testing - Part 2: Tests methods - Test Z/BM: Combined dry heat/low air pressure tests

7.4.2.4 Duration

The test duration specified in the relevant specifications is measured in min (or h or d) and shall be as close as possible to the sequence of numbers: ... 1, 2, 5, 10 ... given with a tolerance of +5%. It shall comply with the requirements of GB/T 2423.58.

7.4.3 Narrowband random vibration

The relevant specifications shall specify the number of narrowband random superimposed on the background acceleration spectral density.

The following requirements shall be made for each narrowband randomly:

- a) Narrowband random bandwidth; the minimum value shall be 0.5%; background random bandwidth does not exceed 10%. The lower limit is not less than 2 times the frequency resolution.
- b) Start-stop frequency of the scan.
- c) Give the sweep frequency speed defined in oct/min or Hz/s, or give the time of one sweep cycle.
- d) Number or duration of narrowband scans.
- e) Sweep logarithmically or linearly.
- f) Starting direction of each scan segment, up or down.
- g) Each narrowband spectrum is specified within the bandwidth of f_1 and f_2 .

When combining all narrowband and background acceleration spectral density values, select the SUM or MAX strategy. See GB/T 2424.26.

7.4.4 Sine wave component

The relevant specifications shall specify the number of sinusoidal components superimposed on the broadband acceleration spectral density. It shall be noted:

- a) Whether there is a harmonic relationship between each other, and their phase relationship.

Note: The phase relationship is for the controller output; the phase relationship of the acceleration signal changes due to the transfer function of the vibration exciter and/or fixture and the specimen.

- b) Start-stop frequency of the sweep.

10 Test

10.1 Test preparation

The relevant specifications shall stipulate that the vibration shall be carried out on one or several axes of the test specimen. When the vibration is specified on several axes during the entire test process, the entire test procedure shall be repeated on each specified axial direction.

For the heat-dissipating test specimen, it shall use the test method without forced air circulation in GB/T 2423.1 test Ad. For heat-dissipating test specimens without cooling devices, when the test chamber (room) is large enough, but only forced air circulation can maintain the test temperature in the chamber (room), method A in Test Ad can be used. When the volume of the test chamber is too small to meet the free air condition, method B in test Ad shall be used. For heat-dissipating test specimens with cooling devices, method A in test Ad can be used. However, the relevant specifications shall stipulate the characteristics of the supplied coolant. If it is air, it shall avoid being affected by oil pollution and humidity.

For the non-heat-dissipating test specimen, it shall adopt the test method of forced air circulation.

10.2 Conditioning test

10.2.1 Vibration test

The combined test chamber (room) is at the temperature of the test room. The test specimen, under the condition of not being packaged and not energized, is installed on the vibrating table according to the specified axle; and then the vibration test is performed according to the severity specified by the relevant specification.

When required by the relevant specifications, the test specimens shall be tested for performance.

10.2.2 Temperature test

The test specimen keeps the installation during the vibration test.

The temperature in the test chamber (room) shall be adjusted to the value specified in the relevant specifications; the temperature of the test specimen shall be stabilized.

The rate control of temperature change in the test chamber (room) shall meet

12 Recovery

At a rate of not more than 10 kPa/min, the air pressure in the test chamber (room) returns to normal atmospheric pressure. During pressurization, temperature control is not necessary. The rate control of temperature change in the test chamber (room) shall meet the requirements of GB/T 2423.22 and return to the normal test room climate state. After that, the test specimen is recovered in the test chamber (room) according to relevant specifications. See Figure 2 and Figure 3.

The test specimen shall be recovered under standard atmospheric conditions. When the standard atmospheric conditions are not suitable for the test specimens, the relevant specifications may specify other recovery conditions. When the test specimen is recovered under standard atmospheric conditions, the recovery time shall be sufficient to make it reach a stable temperature; the minimum time is 1 h. When several test specimens are tested at the same time, and the recovery time of 1 h is not enough, then the longest recovery time is 2 h; so, the measurement shall be completed before the end of this time.

If required by the relevant specifications, then during the recovery period, the test specimen is energized or loaded; its performance is continuously measured.

Note: For the test specimen whose temperature is low, in order to remove the water droplets, the test specimen can be shaken manually; or the air at room temperature can be used for short-time blowing.

13 Final test

In accordance with relevant specifications, the test specimens shall be subject to appearance inspection and electrical and mechanical performance testing.

14 Failure criterion

The failure criterion shall be stipulated by the relevant specifications.

15 Information to be given in the relevant specifications

When the relevant specifications include this test, the details that shall be given are shown in Table 3.

Annex A

(Informative)

Guidelines

A.1 General description

A.1.1 Other applicable standards

The test methods listed in Clause 2 and the relevant basic test principles in the guidelines also apply to this combined test.

A.1.2 Range of test air pressure

This combined test considers the air pressure range commonly used on the ground and aircraft. The air pressure below 1 kPa is not considered.

A.1.3 Choice of heat dissipation method

In the considered air pressure range, the surface temperature of the heat-dissipating test specimen will be greatly reduced under the forced air circulation condition than under the "free air" condition; so, the "free air" condition shall be used for the heat-dissipating test specimen. However, considering the additional thermal interference generated by the vibrating table, and the apparatus cannot meet the "free air" condition, at this time, the forced air circulation test method with wind speed less than 0.5 m/s is allowed.

A.1.4 Determination of the number of samples

Under low air pressure conditions, due to the decrease in the efficiency of convective heat transfer and the increase in the influence of thermal radiation, the mutual thermal interaction between the heat-dissipating test specimens in the same test chamber (room) also increases. In order to avoid thermal interference between heat-dissipating test specimens due to radiation, it is best to test only one test specimen at a time in this test. For non-heat-dissipating test specimens, and heat-dissipating test specimens that are known to have little mutual thermal interference (do not affect the reproducibility of the test), multiple test specimens are allowed to be tested together.

A.1.5 Natural frequency of specimen

Due to the change in material characteristics caused by temperature, the natural frequency of the test specimen (such as rubber or plastic devices) will

characteristics of the monitoring points. For heat-dissipating test specimens, radiation-proof shielding shall be used around the temperature sensor, to reduce the error caused by the thermal radiation of the test specimen.

A.3.2 Air pressure measurement

For air pressure measurement, a thin and long pipe shall usually be used to connect the pressure gauge to the working space; because the use of short and thick connecting pipes may cause the sensor element to be heated or cooled by the gas in the test chamber (room) to produce elastic changes, and measurement errors may occur.

A.3.3 Vibration measurement

The vibration sensor and connecting cable shall be suitable for the specified test temperature and meet the test requirements.

Under different temperature conditions, the influence of temperature on the sensitivity of the vibration sensor shall be considered.

The installation of the vibration sensor shall adopt threaded connection. When the adhesive is used, the adhesive used shall be at the specified test temperature; its physical characteristics shall not change.

A.4 Test apparatus

A.4.1 Functional composition of apparatus

According to functions, the test apparatus used for this test can be divided into: electric vibration test sub-system with mixed vibration mode function; temperature test sub-system with heat, cold and temperature change control functions; low air pressure test sub-system and interfaces between systems. The integrated test system shall be able to meet the requirements of this test.

A.4.2 Apparatus configuration

Unless otherwise specified in the relevant specifications, under normal circumstances, the vibrating table body shall be installed outside the test chamber (room); only the vibrating table surface is extended into the chamber (room). This configuration is more reasonable.

If the vibrating table is installed in the test chamber (room), it will not only make the vibrating table repeatedly suffer the test of the combined environment and affect the life of the vibrating table; but also the heat generated by the vibrating table will interfere with the temperature field in the chamber (room). It shall also be noted that, the vibration transmission characteristics of the vibrating table's

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