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Environmental testing - Part 2: Test methods - Test:

Combined salt mist /temperature/humidity/solar radiation

环境试验 第 2 部分：试验方法 试验：盐雾/温度/湿度/太阳辐射

综合

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Environmental testing - Part 2: Test methods - Test: Combined salt mist /temperature/humidity/solar radiation

1 Scope

This document describes a comprehensive testing method for electrical and electronic equipment, components, and materials under the effects of salt spray, temperature, humidity, and solar radiation, including information on testing equipment, conditions, and methods.

This document is applicable to evaluate the environmental adaptability of electrical and electronic equipment, components, and materials used in humid and hot marine atmospheric environments under the combined effects of salt spray, temperature, humidity, and solar radiation.

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.

GB/T 2423.17, *Environmental testing - Part 2: Test methods - Test Ka: Salt mist*

GB/T 2423.24-2022, *Environmental testing - Part 2: Test methods - Test S: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering*

GB/T 10593.2, *Method of the measuring environmental parameters for electric and electronic products - Part 2: Salt mist*

GB/T 25915.1-2021, *Cleanrooms and associated controlled environments -- Part 1: Classification of air cleanliness by particle concentration*

3 Terms and definitions

There are no terms or definitions that need to be defined in this document.

4 General description of tests

4.1 Overview

This test is a comprehensive test that includes salt spray, dry heat, humid heat, and solar radiation.

Each test cycle of the comprehensive test consists of three stages. The test phase Z1 is composed of humid heat (high temperature, high humidity), salt spray, and solar radiation. The test phase Z2 is composed of dry heat (high temperature, low humidity) and solar radiation. The test phase Z3 consists of humid heat (high temperature, high humidity) and salt spray. Carry out Z1, Z2, and Z3 in sequence to form the basic cycle of the comprehensive test.

4.2 Test phase Z1: Damp heat, salt spray, and solar radiation conditions

Under humid and hot conditions, salt spray, and solar radiation, firstly, the metal part of the specimen undergoes electrochemical or complex chemical reactions and corrosion during the contact process of settling salt droplets. Secondly, the parts of the specimen affected by solar radiation have different abilities to absorb and release light and heat due to material, color, and other characteristics. The process of settling salt solution drying up on the surface of the specimen presents a sequential order, thus reflecting the differences in corrosion effects. At the same time, the solar radiation heat effect can cause deformation between the specimen components, leading to problems such as increased gaps in the original sealed position, which increases the probability of salt spray entering the interior of the specimen in subsequent stages. Finally, a humid and hot environment will maintain the existing humidity in the parts of the specimen surface that are not affected by solar radiation, thereby increasing the penetration time of the electrolyte liquid film into the protective coating of the specimen. The higher ambient temperature also accelerates the corrosion of metal surfaces.

4.3 Test stage Z2: Dry heat and solar radiation conditions

Under dry heat and solar radiation conditions, as the relative humidity decreases, the residual moisture on the surface of the specimen evaporates, and all salt crystals precipitate from the solution and adhere to the surface of the specimen. During this process, the concentration of the liquid film increases and accelerates the chemical reaction, accelerating the corrosion process. At the same time, the thermal effects of solar radiation have directionality and generate thermal gradients, causing different materials and components to expand or contract at different rates, resulting in failure behaviors such as coating blistering and delamination, reduced strength at welding or adhesive sites, seal integrity damage, and softening of encapsulated compounds. In addition, solar radiation can also cause accelerated aging of the protective coating on the surface of the specimen. The photochemical effect can promote the occurrence of loss of light, fading, discoloration, cracking, pulverization or microcracks, thereby

accelerating the penetration of salt solution in the Z3 stage.

4.4 Test phase Z3: Damp heat and salt spray conditions

Under humid and hot conditions, as the relative humidity increases, salt crystals attached to the interior or surface of the specimen absorb water vapor and form a salt solution. At the same time, under salt spray conditions, the salt solution is replenished, ultimately forming an electrolyte membrane on the surface of the specimen to further promote corrosion and penetration. Simultaneously wet the surface of the specimen for the next Z1 stage.

5 Test equipment

5.1 General requirements for test equipment

The materials used for devices directly exposed to salt spray inside the equipment shall not affect the corrosion effect of salt spray. They shall have good sealing performance and corrosion resistance. The materials used for devices directly exposed to solar radiation inside the equipment shall not affect the photothermal aging effect of solar radiation. They shall have good anti-aging performance.

Annex B provides examples of test equipment.

5.2 Equipment installation

5.2.1 Test chamber

The structure of the test chamber and the method of providing salt spray may vary, but the following conditions shall be met.

- a) The operating conditions inside the test chamber are within the specified limits (see Chapter 11).
- b) The determination method of salt spray concentration shall be carried out in accordance with GB/T 10593.2. At least two testing points shall be arranged on the same horizontal plane in the workspace during each test to measure and record salt spray concentration. The deviation of salt spray concentration is within $\pm 30\%$.
- c) The airflow velocity inside the test chamber is controlled below 0.5 m/s. The measurement position is consistent with the irradiation reference plane, facing the direction of the airflow inlet.
- d) The temperature measurement inside the test chamber meets the requirements of GB/T 2423.24-2022.

Other requirements for the test chamber are specified in GB/T 2423 (all parts).

7 Specimens

The type, quantity, shape, and size of the specimen shall be selected according to the relevant specifications of the tested material or product.

If there is no standard, for material specimens, it is advisable to expose at least 3 parallel specimens of each type for statistical evaluation of the results. For equipment and component specimens, both parties can negotiate and determine.

8 Initial testing

Visual, dimensional, and functional inspections shall be conducted on the specimens. If necessary, electrical and mechanical performance testing shall be conducted in accordance with the requirements of relevant specifications.

9 Pretreatment

The specimen shall be pretreated according to relevant specifications and regulations.

The relevant specifications shall specify the cleaning procedure to be used on the specimen before the test. They shall also specify whether the protective coating needs to be removed. The cleaning method used shall not affect the corrosion effect of salt spray on the specimen, and shall not introduce any secondary corrosion. Avoid touching the surface of the specimen with hands before the test.

10 Specimen installation

In the workspace, the arrangement of the specimens shall ensure that they do not come into contact with the test chamber. At the same time, maintain sufficient spacing between the specimens and expose them to freely flowing salt spray. If it is necessary to monitor the surface temperature of the specimen, a temperature sensor can be attached to the specimen according to relevant specifications.

The angle at which the specimen surface is exposed in the test chamber is very important. If there are no relevant regulations, the angle shall be jointly agreed upon by the relevant parties. The specific requirements are as follows:

- For equipment and component specimens, unless otherwise specified, they shall be installed at the same angle as when in terminal use to simulate the final usage conditions of the tested specimen. At the same time, the specimen can be in an unpackaged, non-powered, powered on, or powered on state. Whether the specimen is in a powered working state during the testing process shall be jointly

Before the trial run begins, use a calibrated backup humidity sensor to test the humidity sensor inside the box. When the relative humidity deviation exceeds 2%, the sensor needs to be calibrated.

It is advisable to continuously monitor the specified temperature and relative humidity throughout the entire Test period.

Before the test begins, a no-load test run of at least 8 h shall be conducted to confirm the test conditions. During the trial operation, the salt spray concentration is measured in the workspace after the temperature and relative humidity reach the set test conditions in stages Z1 and Z3. Take the average of 3 measurements as the salt spray concentration value for this stage. If the relevant parties recognize each other, trial operation is not necessary when the time interval between tests is 5 d or less.

In each Test stage, the time required from the start of the test to reach the specified salt spray concentration, temperature, and relative humidity shall not exceed the values listed below:

- Z1 stage: 30 min;
- Z2 stage: 30 min;
- Z3 stage: 60 min.

The above time shall be included in the total time of each stage.

11.3 Test duration

The duration of the test shall be jointly agreed upon by relevant parties. The cyclic test cycle shall be repeated within the duration of the test.

The number of cycles determines the severity of the test.

The recommended duration of the test (number of cycles) is 120 h (15 times) 240 h (30 times) 360 h (45 times), 480 h (60 times), 720 h (90 times), and 960 h (120 times).

12 Intermediate testing

The relevant specifications may propose conducting electrical and/or other performance tests on equipment and component specimens during the testing period. Otherwise, the interruption of the test shall be reduced. The total unboxing time per day shall not exceed 1 h. During this period, the specimen surface shall not be touched or any changes made to the test surface.

NOTE: If considering the consistency issue of irradiance or salt spray deposition in the exposed area of the test specimen, regularly changing the position of the specimen can reduce the uncertainty caused by irradiation and salt spray exposure. The relevant parties agree on the procedure and

schedule for specimen repositioning.

WARNING -- There is a possibility of safety issues such as leakage during or after the test of the energized sample. Specimen testing shall be conducted by professionals or under their guidance.

13 Recovery

The relevant specifications shall specify whether the specimen shall be cleaned. If cleaning is required, follow GB/T 2423.17.

14 Final testing

Visual, dimensional, and functional inspections shall be conducted on the specimens. If necessary, electrical and mechanical performance testing shall be conducted in accordance with the requirements of relevant specifications.

15 Information to be provided regarding the specifications

When the relevant specifications include this comprehensive environmental test, the following detailed information shall be provided.

- a) Initial testing.
- b) Preprocessing.
- c) Installation or support details of the specimen.
- d) The status and precautions of the specimen (powered on, powered off, packaged, unpackaged, etc.).
- e) Test conditions and tolerances:
 - 1) Salt spray concentration;
 - 2) Solar radiation;
 - 3) Temperature;
 - 4) Relative humidity;
 - 5) Duration.
- f) Intermediate testing.

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