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GB/T 5169.40-2015

Fire hazard testing for electric and electronic products - Part 40: Toxicity of fire effluent - Estimation of toxic potency - Apparatus and test method

电工电子产品着火危险试验 第40部分:燃烧流的毒性 毒效评定 装置和试验方法

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1 Scope

This part of GB/T 5169 describes a test method that produces a fire effluent and that identifies and measures the constituents of the combustion products. The method uses a moving test specimen and a tube furnace operated at different temperatures and air flow rates as the fire model. The purpose of the test method is to reproduce one of the decomposition conditions in the series of fire stages described in ISO/TR 9122-1:1989, namely:

stage 1b) non flaming decomposition (oxidative); stage 2 developing fire (flaming); stage 3a) fully developed fire (flaming), vitiated ventilation.

The method described in this part is intended to simulate the three main fire stages above as faithfully as possible, and where necessary other stages may also be simulated. The test measures the fire effluent using material specimens, which may be taken from a finished product or, where the apparatus and the method allow, may be a finished product itself.

The toxic potency value is to be used only in the assessment of the poisoning hazard, and is not to be used on its own.

2 Normative references

The following documents are indispensable for the application of this document. For dated references, only the edition cited applies; for undated references, the latest edition (including all amendments) applies.

GB/T 17650.2-1998, Test on gases evolved during combustion of materials from cables and optical cables - Part 2: Determination of degree of acidity of gases by measuring pH and conductivity (idt IEC 60754-2:1991).

ISO/TR 9122-1:1989, Toxicity testing of fire effluents - Part 1: General.

ISO/TR 9122-4:1993, Toxicity testing of fire effluents - Part 4: The fire model (furnaces and combustion apparatus used in small-scale testing).

ISO/TR 9122-5:1993, Toxicity testing of fire effluents - Part 5: Prediction of toxic effects of fire effluents.

ISO 13344:1996, Estimation of the lethal toxic potency of fire effluents.

ISO/IEC 13943:2000, Fire safety - Vocabulary.

IEC 60695-7-2, Fire hazard testing - Part 7-2: Toxicity of fire effluent - Summary and relevance of test methods.

IEC/TS 60695-7-51, Fire hazard testing - Part 7-51: Toxicity of fire effluent - Estimation of toxic potency: Calculation and interpretation of test results.

DIN 53436-1:1981, Producing thermal decomposition products from materials in an air stream and their toxicological testing; decomposition apparatus and determination of test temperature.

3 Terms and definitions

The terms and definitions given in ISO/IEC 13943:2000 and the following apply to this document.

3.1 lethal exposure dose 50, LCt subscript 50: the product of the volume fraction of the toxic gas that causes the death of 50 % of the test animals under specified conditions and the exposure time. NOTE: its representative unit is cubic centimetres times cubic metres to the power minus one times minutes, as printed in the document.

3.2 mass charge concentration: the mass feed rate of the specimen into the quartz furnace tube divided by the total air flow through the mixing chamber.

3.3 mass loss concentration: the rate of mass loss of the specimen divided by the total air flow through the mixing chamber.

3.4 volatile fraction: the mass loss concentration divided by the mass charge concentration.

3.5 volume yield: the volume of gas produced by unit mass loss of the specimen. NOTE: its representative unit is grams to the power minus one, as printed in the document.

4 Principle

Lethal toxic potency data for the fire effluent of a specimen, obtained from small scale testing, may form part of the data used in the assessment of the poisoning hazard in a fire. The concept of lethal toxic potency comes from tests on rats, on the assumption that the exposure dose of the fire effluent that is lethal to the rat is the same as the dose that is lethal to man. Lethal toxic potency is expressed as the exposure dose of fire effluent that causes the death of 50 % of the exposed rats, denoted LCt subscript 50; it depends on the concentration of the toxic fire effluent and may be expressed in several forms, the one most used being a parameter based on the mass charge concentration or the mass loss concentration of the material under test.

Early assessments of toxic potency were made by animal exposure tests. Today most specimens are assessed for toxic potency from the results of a chemical analysis of the gaseous constituents of the fire effluent, and for that reason the method described in this part plans for measurement by chemical analysis, although the animal exposure test remains applicable.

To assess toxic potency by that method, the following are needed: a) a method for decomposing the specimen under set conditions representing different fire stages, and for measuring the concentration and the yield of the selected constituents of the fire effluent; and b) a method for calculating the lethal toxic potency of the fire effluent from the concentration and the yield of the selected constituents (see IEC/TS 60695-7-51).

Many calculation methods for assessing the toxic potency of the fire effluent of a specimen have been developed and are published in ISO/TR 9122-5:1993. To use those calculation methods, yield data are needed for the main toxic products of the specimen under a series of fire conditions; these can be obtained from many of the existing small scale combustion toxicity test methods. Many of the existing test methods, however, are based on a flawed fire model or can reproduce the decomposition conditions of only a small part of the fire stages shown in ISO/TR 9122-4:1993 (see Table 1). IEC 60695-7-2 outlines those tests and gives guidance on selecting and using the fire effluent toxicity test methods.

5 Background

The small scale test methods for determining the toxic potency of the fire effluent are outlined in IEC 60695-7-2.

The tube furnace method of DIN 53436-1:1981 is a widely applied test method. It builds a reasonable model of the decomposition conditions for each fire stage separately, it is inexpensive and easy to operate, and it can be developed into a more general method applicable to all the fire stages in Table 1.

Table 1, which follows ISO/TR 9122-1:1989, divides the fire stages approximately and sets, for each stage, the oxygen volume fraction in per cent, the ratio of carbon dioxide to carbon monoxide, the temperature in degrees Celsius and the irradiance in kilowatts per square metre; the table has five columns, one for the stage and four for those quantities. Stage 1, non flaming decomposition, has three rows: a) smouldering, self sustaining, with oxygen 21, the ratio not applicable, temperature below 100 and irradiance not applicable; b) non flaming oxidative, with oxygen 5 to 21, the ratio not applicable, temperature below 500 and irradiance below 25; c) non flaming pyrolytic, with oxygen below 5, the ratio not applicable, temperature below 1 000 and irradiance not applicable. Stage 2, developing fire with flame, has oxygen 10 to 15, ratio 100 to 200, temperature 400 to 600 and irradiance 20 to 40. Stage 3, fully developed fire with flame, has two rows: a) vitiated ventilation, with oxygen 1 to 5, ratio below 10, temperature 600 to 900 and irradiance 40 to 70; b) good ventilation, with oxygen 5 to 10, ratio below 100, temperature 600 to 1 200 and irradiance 50 to 150. Three footnotes state that the oxygen and temperature figures are the general ambient conditions of the compartment as mean values, that the ratio is the mean value in the fire plume near the fire, and that the irradiance is the mean value received by the test specimen.

Of the fire stages described in Table 1, the ones that usually matter most are stage 1b), non flaming decomposition (oxidative); stage 2, developing fire (flaming); and stage 3a), fully developed fire (flaming) with vitiated ventilation. The decomposition conditions of the recommended test method resemble fire stages 1b) and 3a) and simulate stage 2 as far as possible; where required, the method can also simulate the other fire stages. The decomposition conditions of these fire stages are characterised by the temperature, the combustion behaviour and the ratio of carbon dioxide to carbon monoxide. Assessment of other tube furnace methods has also shown that they can provide the decomposition conditions of several different stages of a real fire.

6 Test method

6.1 Outline. The test method described in this part has the same principle as DIN 53436-1:1981. GB/T 17650.2-1998 gives the types of tube furnace and quartz tube that have wide applicability, together with their known performance under the specified test conditions.

6.1 (continued). The specimen used in the test is in granular or strip form and is fed into the quartz furnace tube at a constant rate. The quartz tube is heated by the tube furnace, and primary air is passed through the quartz tube over the specimen to support combustion. The fire effluent leaves the quartz tube, enters the mixing test chamber and is diluted by secondary air; the effluent is then analysed and discharged.

6.1 (continued). The decomposition conditions in the quartz furnace tube are set by using different temperatures and primary air flow rates, so as to simulate the fire stages of ISO/TR 9122-1:1989. The sentence continues beyond the last page available for this record