ICS 13.220.40; 29.020
CCS K 04

NATIONAL STANDARD OF THE PEOPLE'S REPUBLIC OF CHINA

GB/T 5169.41-2015

Fire hazard testing for electric and electronic products - Part 41: Toxicity of fire effluent - Estimation of toxic potency - Calculation and interpretation of test results

电工电子产品着火危险试验 第41部分:燃烧流的毒性 毒效评定 试验结果的计算和说明

Issued on: October 9, 2015 **Implemented on: May 1, 2016**

Issued by: State Administration for Market Regulation;
Standardization Administration of the PRC

Table of Contents

1 Scope

This part of GB/T 5169 describes the calculation procedure for converting the data obtained by the chemical analysis method of GB/T 5169.40-2015 into toxic potency data for the material under test under specified conditions. The aim is to assess the part that the fire effluent of a product or material plays in the threat to life from the total fire effluent in the fire situation in which the product or material finds itself.

Where the data format of another relevant test method agrees with that specified in GB/T 5169.40-2015, that kind of data may also be converted into predetermined toxic potency values.

The principle of the method agrees with the improved principle of IEC 60695-7-3:1998 and ISO/TR 9122-5:1993, and the results are expressed in the format used by the laboratory test method of GB/T 5169.40-2015.

A toxic potency value is used only for the assessment of toxic hazard and shall not be used on its own.

3 Terms and definitions

The terms and definitions of ISO/IEC 13943:2000 and the following apply.

3.1 Effective dose 50, symbol ECt50: the exposure dose of an inhaled toxic substance that produces a specified observed effect in 50 % of the individuals of the same species exposed under the same laboratory conditions, expressed as volume fraction multiplied by time, Ct. A note adds that the representative phenomena of the observed effect are

incapacitation or death, and that the lethal ECt50 dose is written LCt50, that is, the median lethal exposure dose.

3.2 Fractional effective dose (FED): for the same fire effluent, the ratio of the exposure dose Ct to the effective exposure dose ECt50. A note adds that when FED equals 1, the specified effect, incapacitation or death, is expected to occur.

3.3 Fraction of lethal dose (FLD): for the same fire effluent, the ratio of the exposure dose to the lethal dose. A note adds that in this case the FED is the value at which the observed toxic effect is lethal.

3.4 Incapacitation: the condition in which the body, because of exposure to a toxic substance, is unable to carry out a specified task, one connected with escaping from the fire.

3.5 Volume yield, symbol X: when the test is carried out with the tube furnace described in GB/T 5169.40-2015, the volume of gas produced per unit mass loss of the specimen.

4 Principle of the test method

The principle of the test method is that, when a product or material is tested with the apparatus and the test method described in GB/T 5169.40-2015, the FED value of the accumulated toxic products is calculated from the fire effluent exposure of that product or material in the fire situation in which it finds itself.

Because the calculation is based on chemical analysis, the assessment of the true FED value lacks biological verification. Also, unforeseen toxic constituents may be present that have not been chemically analysed, so the true FED value is generally higher than the predicted FED value.

5 Test method

5.1 Outline: the total toxic effect of the fire effluent is the sum of the separate actions of each toxic constituent. Where only the product or material under test produces the fire effluent, the inhaled fractional effective dose FED is obtained by formula (1) as the sum, over all toxic constituents, of the exposure dose of toxic constituent i divided by the potency of toxic constituent i producing that effect. Lethality is usually the end point of toxicity; however, where suitable toxic potency data are available for components, other kinds of end point such as incapacitation can also be used. The FED value is related to the results of the toxic potency test as follows: the volume of toxic constituent i is obtained by formula (2) as the volume yield of constituent i in the toxic potency test multiplied by the mass loss of the specimen during the exposure time; the volume fraction of toxic constituent i is obtained by formula (3), which divides that volume by the volume of the fire effluent; and the exposure dose of toxic constituent i is obtained by formula (4), which introduces the mass loss concentration integral, that is the integral over the exposure time of the ratio of the mass

loss to the volume of fire effluent. Substituting formula (4) into formula (1) gives formula (5). Where more than one material or product burns and all the combustion products are part of the same fire effluent, the same principle applies and the total FED is obtained by formula (6), summed over all the substances. The FED calculated in this way is a valid assessment only when the fire situation is at the same fire stage as that at which the volume yield values were measured in the toxic potency test, see Table 1 of GB/T 5169.40-2015 and ISO/TR 9122-1:1989.

5.2 Calculation of the toxic potency of a fire effluent predicted from the FED principle: from the data obtained in the combustion test, the following values are determined for each fire effluent constituent, that is carbon dioxide, carbon monoxide, hydrogen cyanide and so on: y, the mass yield, dimensionless; d, the density, for example 1,83 grams per cubic decimetre for carbon dioxide and 1,17 grams per cubic decimetre for carbon monoxide; and X, the volume yield, equal to y divided by d. Assuming a specimen mass loss of 1 g whose fire effluent has an ideal diffusion volume of 1 cubic metre, the volume fraction C, expressed in cubic centimetres per cubic metre, is 1 000 000 grams per cubic metre multiplied by y divided by d. The exposure dose over 30 min is D equal to 30 min multiplied by C. The FED of each fire effluent constituent is calculated by formula (7), the exposure dose divided by the LCt50, in which case the FED is the FLD. The LCt50 values are equal to the LC50 reference values given in ISO 13344:1996 multiplied by the exposure time corresponding to those values, that is 30 min. Examples of LC50 values are 100 000 cubic centimetres per cubic metre for carbon dioxide and 5 700 cubic centimetres per cubic metre for carbon monoxide. Examples of LCt50 values are 3 000 000 cubic centimetres per cubic metre multiplied by minutes for carbon dioxide and 171 000 for carbon monoxide. The total FED of the fire effluent is the sum of the individual FED values of each fire effluent constituent, and the mass loss per cubic metre is the reciprocal of the sum when the total FED equals 1. The predicted toxic potency of the total fire effluent, for a specimen mass loss of 1 g diffused into a volume of 1 cubic metre, is obtained by formula (8) as 30 divided by the total FED, in grams multiplied by minutes per cubic metre.

A Annex A (informative) Example

Example results obtained by the method of GB/T 5169.40-2015 are given in Table A.1 and Table A.2.

Table A.1, headed Results of a typical example, has a parameter column, a unit column and four constituent columns for carbon dioxide, carbon monoxide, hydrogen cyanide and hydrogen chloride. The mass yield, in grams per gram of mass loss, is 0,56 for carbon dioxide, 0,15 for carbon monoxide, 0,28 for hydrogen cyanide and 0 for hydrogen chloride. The gas density, in grams per cubic decimetre, is 1,83, 1,17, 1,13 and 1,52 respectively. The volume yield, in cubic decimetres per gram of mass loss, is 0,31, 0,13, 0,25 and 0. The volume fraction, based on 1 cubic metre and expressed in cubic centimetres per cubic

metre, is 306, 128, 248 and 0. The dose, based on an exposure of 30 min and expressed in cubic centimetres per cubic metre multiplied by minutes, is 9 180, 3 846, 7 434 and 0. The LC50 reference value, in cubic centimetres per cubic metre, is 100 000, 5 700, 165 and 3 800. The LCt50 reference value, in cubic centimetres per cubic metre multiplied by minutes, is 3 000 000, 171 000, 4 950 and 114 000. The FED of each constituent is 0,003, 0,022, 1,502 and 0.

Table A.2, headed Calculation of the toxic potency, has four rows: the total FED, based on 1 g of mass loss per cubic metre, is 1,53; the mass loss per unit volume at which FED equals 1 is 0,65 grams per cubic metre; the exposure time is 30 min; and the predicted toxic potency of the fire effluent is 19,64. The unit printed for this last row in the table is g.m3.min.

The text below the tables states that the above results mean that when the fire effluent produced by a loss of 19,64 g of specimen is diffused into a volume of 1 cubic metre, a 50 % death rate is expected among the test animals after 1 min of exposure to such an environment.

B Annex B (informative) Example: calculation of the FLD for a postulated fire from tube furnace interlaboratory test data

A note states that the FLD is the calculated result under a specified fire situation.

B.1 Assumptions: the toxic constituents are carbon dioxide, carbon monoxide and hydrogen cyanide; the exposure time is 15 min; the burning rate of the material is 0,1 kg per minute; the enclosure volume holding the fire effluent is 50 cubic metres; the fire stage is 3a, see Table 1 of GB/T 5169.40-2015, complete combustion with flame and poor ventilation.

B.2 Known reference data, the toxic potency of the toxic gas constituents: the source is ISO 13344:1996; the toxic action reported is lethal, so the calculation of the FED refers to the median lethal dose fraction LCt50, accumulated over 15 min of exposure to the fire effluent. For carbon dioxide the LCt50 is 3,0 million cubic centimetres per cubic metre multiplied by minutes, that is 3,0 min; for carbon monoxide it is 1,7 hundred thousand cubic centimetres per cubic metre multiplied by minutes, that is 0,17 min; for hydrogen cyanide it is 5,0 thousand cubic centimetres per cubic metre multiplied by minutes, that is 0,005 0 min.

B.3 Calculation: since only a single burning article is involved, formula (5) is substituted to give formula (B.1), the FLD as the mass loss concentration integral multiplied by the sum over all toxic constituents of the volume yield divided by the LCt50; formula (B.2) writes the same expression out for carbon dioxide, carbon monoxide and hydrogen cyanide.

B.3.1 Mass loss integral: with a steady burning rate of 0,1 kg per minute maintained for more than 15 min and an enclosure volume of 50 cubic metres, the total mass loss is 0,1 kg per minute multiplied by the time, and combining this with formula (4) gives, in formula (B.3), a mass loss integral of 0,225 kg multiplied by minutes per cubic metre.