INTERNATIONAL STANDARD

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Plastics — Smoke generation — Determination of the corrosivity of fire effluents —

Part 3:
Dynamic decomposition method using a travelling furnace

Plastiques — Production de fumées — Détermination de la corrosivité des effluents du feu —

Partie 3: Méthode dynamique de décomposition utilisant un four mobile

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Foreword

ISO (the International Organization for Standardization) is a world-wide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard 11907-3 was prepared by Technical Committee ISO/TC61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

ISO 11907 consists of the following parts, under the general title *Plastics – Smoke generation – Determination of the corrosivity of fire effluents*:

– *Part 1: Guidance*
– *Part 2: Static method*
– *Part 3: Dynamic decomposition method using a travelling furnace*
– *Part 4: Dynamic decomposition method using a conical radiant heater*

Annex A forms an integral part of this part of ISO 11907. Annexes B and C are for information only.

Introduction

This method of test is one of a series being developed by ISO/TC61/SC4 concerning fire tests on plastics and other combustible materials to help assess the corrosivity of their fire effluents.

This test was developed in close connection with the work done in ISO/TC92/SC3.

During a fire, hot and humid smoke may be carried throughout the building, and its various products may condense and settle down on the surfaces of walls, floors and e.g. machines and electronic equipment. In principle, smoke should always be expected to have a corrosive action, irrespective of the composition of the material. Corrosion is generally defined as decomposition, beginning at the surface, of metallic and non-metallic materials. The degree of damage, however, is specific both to the composition of the smoke and to the nature of the materials. The concentrations of the harmful substances depend on e.g. the ventilation and the scale of the fire, while the loss itself depends partly on factors unrelated to the actual fire, such as the air conditions in the rooms of the building, the hygroscopic behaviour of the construction materials and the nature, scale and timing of the rebuilding work.

Plastics – Smoke generation – Determination of the corrosivity of fire effluents –

Part 3:
Dynamic decomposition method using a travelling furnace

WARNINGS

1 Avoidance of misleading inferences

This standard method of test should be used solely to measure and describe the properties of materials, products or systems in response to heat or flame under controlled laboratory conditions and should not be considered or used by itself for describing or appraising the fire hazard of materials, products or systems under actual fire conditions or as the sole source on which regulations pertaining to the corrosivity of fire effluents are based.

2 Avoidance of danger to test operators

a) This test procedure involves combustion processes in which fire hazards may exist from combustion products. To avoid accidental leakage of hazardous combustion products into the surrounding atmosphere, the entire system (combustion apparatus and exposure system) should be placed in a fume cupboard or under a canopy hood.

b) The venting system shall be checked for proper operation before testing and shall discharge into an exhaust system with adequate capacity.

c) As, in unfavourable circumstances, extremely rapid combustion or explosion can occur when the device is in operation, a protective screen between the operator and the tube is recommended and, in addition, care should be taken to ensure that the gas outlet at the end of the quartz tube is of as large a diameter as possible.

1 Scope

1.1 This part of ISO 11907 specifies a test method for generating thermal decomposition products from plastic materials or products in an air stream and assessing the corrosive effects of these fire effluents on targets. It is not intended that the results be used to assess the corrosivity hazard of fire atmospheres.

1.2 It describes a dynamic decomposition test method for the assessment of the corrosion damage of a standardized target by the change in its electrical resistance.

1.3 The decomposition model is suitable for simulating the main fire scenarios, such as a smouldering fire, a developing fire with flame formation, and a fully developed fire. The decomposition model enables a constant flow of smoke to be maintained throughout the exposure time.

The decomposition model and exposure model enable the potential for a contribution to corrosivity to be estimated.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 11907. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 11907 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 11907-1:1998, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 1: Guidance.*

ISO 11907-2:1995, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 2: Static method.*

ISO 11907-4:1998, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 4: Dynamic decomposition method using a conical heater.*

3 Definitions

For the purposes of this part of ISO 11907, the following definitions apply.

3.1 corrosion: The reaction of a metallic material with its environment, resulting in a measurable change of the material and possibly in an impairment of the functioning of a metal part or of an entire system.

NOTE – In most cases, the reaction is electrochemical. In others, however, it may be chemical (non-electrochemical) or physical.

3.2 corrosion damage: The physical and/or chemical damage or impaired function caused by chemical action.

3.3 fire effluent: The totality of gases and/or aerosols (including suspended particles) created by combustion or pyrolysis.

3.4 fire model: A laboratory process, including the apparatus, the environment and the test procedure, intended to represent a certain phase of a fire.

3.5 fire scenario: A detailed description of conditions, including environmental, of one or more stages from before ignition to completion of combustion in an actual fire at a specific location, or in a real-scale simulation.

3.6 corrosion target: The sensor used to determine, under specified test conditions, the degree of corrosion damage.

NOTE – This sensor can be a product, a component or a reference material used to simulate them.

4 Principle

An annular furnace is set to a specified temperature and is moved over the test specimen located in a quartz cuvette inside a quartz glass tube through which air is passed at a specified flow rate. The conditions can be chosen to simulate a smouldering or developing fire as well as a developed fire (see ISO 11907-1). A corrosion target consisting of a copper printed wiring board is exposed to the fire effluents and condensation is enhanced by using a cooling system. Condensed products react with the copper if they are corrosive, and the change in resistance of the target is used to denote the corrosion hazard.

5 Apparatus

5.1 Combustion apparatus

5.1.1 The combustion apparatus consists of a quartz tube (see 5.1.2), an annular furnace (see 5.1.3), a flow meter (see 5.1.4) and a cuvette (see 5.1.5), generally arranged as shown in figure 1 (see also 6.1).

5.1.2 The quartz tube is $\left(1\,000\,^{+300}_{0}\right)$ mm long with an outer diameter of (40 ± 1) mm and a wall thickness of (2 ± 0,5) mm

5.1.3 The annular furnace, which encloses the quartz tube, is (100 ± 1) mm long and able to traverse the quartz tube coaxially at a speed of (10 ± 0,5) mm/min.

NOTE – Furnaces with the temperature distribution as required in 6.2.3 are commercially available.

The power of the furnace shall be capable of maintaining the temperature required in 6.2.

The furnace heater incorporates a thermocouple used to regulate the temperature of a reference body in conformance with 6.2.3.

5.1.4 The flow meter is capable of measuring air flow per minute (fresh/room air) with an accuracy of 2 %.

5.1.5 As sample holder, a cuvette is used. The cuvette is half a quartz tube with a wall thickness of (1,7 ± 0,2) mm, a height of (15 ± 1) mm and a length of $(400\,^{+10}_{0})$ mm. At each end of the cuvette, there is a 2 mm high lip (see figure 2).

5.1.6 An environmental chamber capable of conditioning at (23 ± 2) °C and (50 ± 5) % RH shall be provided.

5.1.7 An environmental chamber for post-test exposure of the target at (23 ± 2) °C and (75 ± 5) % RH shall be provided.

5.2 Reference body

The reference body consists of a strip, measuring (200 ± 1) mm × (5 ± 0,1) mm × (2 ± 0,1) mm, of austenitic stainless steel. In the middle of the reference body, there is a groove, typically 1 mm deep, 1,2 mm wide and 10 mm long, in which a thermocouple (NiCr-Ni or chromel-alumel) with 1 mm outside diameter is hard-soldered with high-melting silver. The reference body is supported on the underside by two transverse rods of (1 ± 0,1) mm diameter (see figure 3).

In use, the reference body shall be connected to a temperature recorder providing readings to an accuracy of ± 0,5 %.

Before the first measurement, the reference body shall be annealed in air twice at a temperature of (550 ± 50) °C.

5.3 Timing device

The timing device shall be capable of recording elapsed time to the nearest second and shall be accurate to within 15 s in 1 h.

5.4 Corrosion target

The corrosion target shall consist of a copper printed wiring board (PWB) circuit (see figure 4) made by etching a copper-plated laminate base to provide 36 conductor tracks each 52 mm long, 0,3 mm wide and 17 µm thick, at a spacing of 0,3 mm, on a laminated epoxy baseplate having the following characteristics:

Dimensions: $\left(30\,^{0}_{-0,3}\right)$ mm × $\left(60\,^{0}_{-0,3}\right)$ mm × $\left(1,5\,^{0}_{-0,3}\right)$ mm

Resistance: (8,0 ± 0,5) Ω

5.5 Holder with cooling system

The target holder shall enable one copper PWB to be cooled during the exposure, as shown in figure 5. It shall be made from a stainless-steel block. The cooling water shall flow through two horizontal bores which are connected by a vertical bore. The lower and upper openings of this bore shall be closed. The target shall be attached with two clamps, e.g. as shown in figure 5.

Unless otherwise specified by the referring standard (in relation to a special test objective), normal tap water at (15 to 30) °C shall be passed through the cooling system at a flow rate of approx. 1,5 l/min.

5.6 Alternative corrosion targets

In annex A, examples of alternative corrosion targets are listed. If one of these targets is used, the procedure as described in annex A shall be followed.

5.7 Balance

The balance shall be capable of weighing to an accuracy of ± 0,01 g

5.8 Resistance-measuring device

The device shall be capable of measuring resistance to an accuracy of ± 0,01 Ω over the range (5 to 15) Ω.

6 Setting-up and calibration procedures

6.1 Siting of the apparatus

Site the apparatus in a laboratory fume cupboard (exhaust hood) so that the test is carried out in a substantially draught-free atmosphere.

6.2 Calibration

6.2.1 Measuring the test temperature

Determine the test temperature and the temperature distribution (see 6.2.3 and 6.2.4) periodically using the reference body.

6.2.2 Test sequence

6.2.2.1 Locate the furnace in position 1 (see figure 1) and set it to maintain the required temperature. After the furnace temperature has stabilized, check it using the reference body (5.2) as follows:

Put the reference body in the quartz tube half way between positions 1 and 2 of the furnace, connect the air duct to the quartz tube and set it to the air flow required. Unless otherwise specified by the referring standard, pass air at (100 ± 5) l/h through the quartz tube. Traverse the furnace to position 2 at (10 ± 0,5) mm/min (see figure 1).

Record the highest temperature observed as the reference body temperature.

6.2.2.2 Repeat the procedure of 6.2.2.1 to obtain at least three measurements using the same furnace temperature. If necessary, adjust the equipment until the deviation of three successive individual results from their average is within 3 %.

6.2.3 Temperature distribution

The variation of the reference body temperature with time shall conform to table 1 with the air flow set at (100 ± 5) l/h. The time $t(T_{max})$ used in table 1 is the time taken for the temperature to reach its maximum value T_{max}. The reference body temperature 5 min and 10 min either side of this time shall be as given in table 1.

Table 1

Elapsed time after setting furnace in motion minutes	**Temperature at measurement point** % of T_{max}
$t(T_{max}) - 10$	15 ± 10
$t(T_{max}) - 5$	65 ± 10
$t(T_{max})$	100
$t(T_{max}) + 5$	70 ± 10
$t(T_{max}) + 10$	45 ± 10

6.2.4 Test temperature

Take the test temperature to be the average of the three reference body temperatures.

6.2.5 Reference curve

By plotting a graph of furnace temperature versus reference body temperature over a series of test conditions, obtain the operating reference curve for the apparatus. From this, it is possible to establish the furnace temperature required to heat a given reference body to between 200 °C and 800 °C at a given air flow rate.

6.3 Preparation of the PWB

Prepare the PWB by cleaning with a pumice-based acidic powder formulation. Rub the PWB with a piece of moist cotton wool containing the cleaning powder. Thoroughly wash the PWB with deionized water and carefully wipe it dry.

NOTE – By this method, copper surfaces are cleaned chemically as well as physically. The acidic chemical cleaning action removes oxides and wets the PWB surface. No residual film remains after rinsing and drying. Circuits which have been subjected to this treatment show no sign of corrosion in simple condensation tests.

Solder two insulated copper wires, each approximately 0,5 m long, to the end points of the conductor track.

7 Preparation of test samples

7.1 Number of test samples

Carry out each test in triplicate.

7.2 Homogeneous specimens

Determine the specific density (mass per unit area) of each specimen by measuring its dimensions to within ± 0,1 mm and weighing it to within ± 0,05 g.

If the density is greater than or equal to 400 kg/m^3, then cut the specimen to a size of $l \times w \times d$ = 400 mm × 15 mm × 2 mm.

If the density is less than 400 kg/m^3, the thickness of the specimen is measured so that the mass per unit length (g/cm) is equal to that of a material with a density of 400 kg/m^3.

i.e.:
For a material with density ρ = 400 kg/m³,

$$\frac{m}{l} = \rho \times w \times d$$

Since the width $w = 1{,}5 \times 10^{-2}$ m, and $d = 2 \times 10^{-3}$ m

$$\frac{m}{l} = 1{,}2 \times 10^{-2} \text{ kg/m}$$

If the density ρ of a material is 40 kg/m³, then the sample thickness d may be calculated as follows:

$$d = [1{,}2 \times 10^{-2} \text{ kg/m}] [40 \text{ kg/m}^3 \times 1{,}5 \times 10^{-2} \text{ m}]$$
$$= 0{,}02 \text{ m}$$

7.3 Films and fabrics

Arrange cut sections of films and fabrics in layers so that the total mass distributed evenly over the length of specimen is between 3,6 g and 7,2 g. The number of layers as a function of the mass per unit area m_a shall conform to table 2.

Table 2

Mass per unit area, m_a g/m²	**Number of layers**
≤ 200	6
> 200 and ≤ 300	4
> 300 and ≤ 400	3
> 400 and ≤ 600	2
> 600	1

7.4 Laminates

Separate each layer of a laminated material or product to enable each type of layer to be tested individually, stacked in conformance with table 2 as applicable.