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Room corner and open calorimeter — Guidance on sampling and measurement of effluent gas production using FTIR technique

Mesurage de la production de gaz toxique à l'aide de la technique IRTF pour l'essai en coin de salle et calorimétrie ouverte

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth*.

Introduction

This International Standard is intended to obtain concentrations of effluent gases produced in large-scale or simulated real-scale fire tests, such as the room corner test and open calorimeters. These tests describe the fire behaviour of a product under controlled laboratory conditions.

The test standard can be used as part of a fire hazard assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of a particular end use.

Room corner and open calorimeter — Guidance on sampling and measurement of effluent gas production using FTIR technique

1 Scope

This International Standard gives guidance concerning suitable apparatus and procedures to be used when applying the FTIR method to measure concentrations of effluent gases produced in large-scale or simulated real-scale fire tests. Such tests include the room corner test (see ISO 9705) and open calorimeter tests as described in ISO 24473.

This guidance and measuring method only describes the way in which the sampling of the gases and collection of FTIR spectra are performed. Analysis of spectra and calibration is part of ISO 19702.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9705, *Fire tests — Full-scale room test for surface products*

ISO 13943, *Fire safety — Vocabulary*

ISO 19702:—[1], *Guidance for sampling and analysis of toxic gases and vapours in fire effluents using Fourier Transform Infrared spectroscopy (FTIR)*

ISO 24473, *Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995)*

3 Terms and definitions

For the purposes of this document, the definitions given in ISO 13943 apply.

4 Principle

By using the on-line FTIR technique, it is possible to simultaneously measure the time resolved concentration of several gases during a fire test.

The practical measurement procedure is to continuously extract a fraction of the effluents from the exhaust duct (the most common application) from the opening of the test room or, alternatively, from a position in the vicinity of a test object through a heated sampling system and into a heated optical cell. There, the specific absorption patterns of infrared-active species are recorded by a detector. This information is subsequently presented as an absorption spectrum that is used to determine the concentrations of effluent components. The frequency of collection of absorption spectra, the

1) To be published. (Revision of ISO 19702:2006)

characteristics of the flow in the exhaust duct (if applicable), and the residence time and flow pattern in the optical cell determine the time resolution of the measurements.

NOTE FTIR is based on infrared absorption. Polyatomic and heteronuclear diatomic compounds have absorption in the infrared region. Specific to FTIR is conversion of regular irradiance from a broad band infrared source into interfered irradiance by an interferometer and conversion of the recorded interferogram into a conventional wavelength spectrum. The main advantage of the FTIR technique is that information from all spectral elements is measured simultaneously and another advantage is that the measurement is made with a high optical throughput giving a high signal to noise ratio. See ISO 19702 for a more detailed background on FTIR theory.

5 Gas sampling system

5.1 General

The gas sampling system consists of a probe for sampling fire effluent gases, a filter system for removing particulates from the sampled gas, sampling tubing for transporting the gas to the FTIR gas cell, and a pump for drawing the gas. The parts of the sampling system placed before the FTIR gas cell shall be heated to avoid condensation and losses of certain water soluble compounds (e.g. HCl).

A temperature of the sampling system between 150 °C to 190 °C shall be used (see ISO 19702).

The temperature throughout the heated part of the sampling system shall be homogeneous or slightly increasing along the sampling system from the probe to the gas cell to avoid any cold points that could act as a condensation point for water and soluble gases.

NOTE 1 It is important that the gas in the sampling system is heated to a temperature as close as possible to the set-temperature of the sampling system. Procedures for checking the gas temperature are given in ISO 19702.

Information on delay and response time of the overall system is necessary and shall be reported.

NOTE 2 Method for determination of the response and transport time of the measurement system is given in ISO 19702. Besides the transport time from the gas sampling probe to the gas cell, there is also a transport time from the room to the gas sampling probe.

NOTE 3 The response and delay time can be obtained at the same time as burner calibrations are performed (see ISO 9705). It also allows an overall check of the system.

5.2 Gas sampling probe

5.2.1 Sampling position

In enclosure tests, the normal sampling position is in the duct of the smoke collection system. This sampling position represents cooled and diluted fire effluents.

NOTE 1 This sampling position is preferred in many cases as matrix effects from the fire effluents are minimized by the dilution. A further advantage is that when fire effluents are quantitatively collected with the hood system, the production of toxic gases can be quantitatively measured.

NOTE 2 In the early stages of an enclosure fire or when sampling from a small fire in an enclosure, the dilution of the fire effluents can result in concentrations below practical detection limits.

An alternative sampling position in an enclosure test, which can be preferred in certain cases, is in the top of the doorway (i.e. sampling from the undiluted out-flowing fire effluents).

NOTE 3 For sampling from the doorway, it is important to ascertain that a representative sample is taken over the out-flowing area. It is further important to consider that hot fire gases sampled from the opening might not be sufficiently oxidized and will continue to react outside of the opening.

NOTE 4 For quantitative measurement of toxic gas production, the flow rate out from the room has to be quantified.

Another alternative sampling position in an enclosure test is at various local positions within the enclosure.

NOTE 5 The results from measurements at specific positions within an enclosure are, however, only relevant for the specific test scenario.

In open tests where the fire effluents are collected by a hood/smoke gas collection system, the normal sampling position is in the duct of the smoke collection system.

Alternative sampling positions in open tests are at various local positions in the vicinity of the fire.

NOTE 6 The results from point measurements in the vicinity of the fire are, however, only relevant for the specific test scenario.

5.2.2 Exhaust duct sampling application

The gas sampling probe shall extract a representative sample of gases from the exhaust duct.

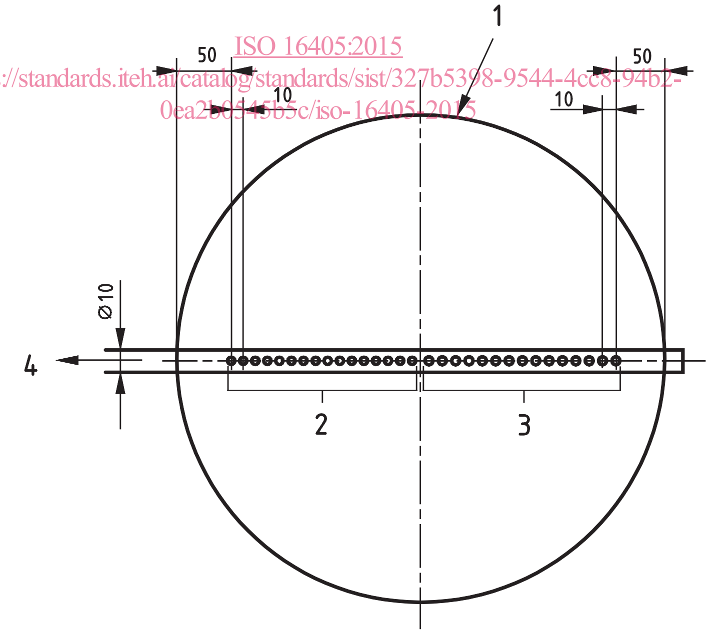
The probe shall be mounted at a position in the smoke gas duct where the diluted fire effluents are uniformly mixed.

NOTE 1 This is normally the case at a distance of 5 diameters to 10 diameters from the bend of the duct after the collection hood.

NOTE 2 A suitable probe construction and arrangement for the ISO 9705 test is shown in Figure 1 (information on probe positioning is available in ISO 9705, Annex E).

NOTE 3 General information on sampling probes for FTIR-measurement is available in ISO 19702.

Dimensions in mm



Key

1 exhaust duct

2 16 Ø 2 mm holes on downstream side of flow

3 15 Ø 3 mm holes on downstream side of flow

4 connection to the sampling line

Figure 1 — Gas sampling probe for the ISO 9705 room exhaust duct

5.2.3 Alternative sampling applications

When sampling directly from poorly mixed and inhomogeneous fire gases (for example, in the door opening of a test enclosure), one shall ascertain representative sampling.

NOTE 1 The flow patterns through the opening of a test enclosure are complicated and it varies during the course of a fire test. Typically, the upper part of the exit flow is well-mixed but this is surrounded by a relatively slow-moving boundary layer between effluent and air that can be partly diluted by the incoming air. Ideally, it is useful to observe the flow shape and characteristics for the particular test before selecting a probe type and its position in the effluent stream. It is likely that a multi-hole probe will be necessary.

One method to accomplish representative sampling is to use a multi-hole probe with gradation of hole sizes along the length of the probe and to place the probe such that it crosses the fire gases monitored.

NOTE 2 An example of a suitable multi-hole probe is given in Table 1. This probe has been successfully applied to measurements taken in the door of the ISO 9705 room, where the top of the probe (closest to the pump) was placed at the top of the ISO 9705 door and the probe traversed the door diagonally, finishing 30 cm below the top of the doorway.[3]

A simpler but less precise method is to place a single-port probe in a well-mixed location; in a door opening, the probe shall be placed in the relatively well-mixed upper layers of the out-flowing effluents.

Measurement of the volumetric exit flow rate from a door opening is necessary whatever probe type is used in order to convert measured concentrations to total flow of gas species out from the test enclosure.

NOTE 3 The exit flow in enclosure fire tests varies during a test. The rate of the exit flow grows with increasing fire intensity and the position of the neutral plane stabilises first at “steady-state” where the fire growth is relatively stable (e.g. due to ventilation control of burning rate rather than fuel involvement control of burning rate).

NOTE 4 The exit flow can be measured using traditional velocity probes such as pitot tubes, McCaffrey probes, or more advanced optical methods such as particle image velocimetry. It is, however, not always possible to directly measure the exit flow using velocity probes as the pressure difference over the opening is relatively small and the often turbulent outflows in the opening have velocity components in directions other than the normal direction to the exit plane.

NOTE 5 An alternative method is to calculate the exit flow based on the pressure difference between the room and outside and the height of the neutral plane (i.e. a virtual horizontal plane separating the outgoing effluent from the incoming air) in the stratified case. An example of this method is given in Reference [4] and more details can be found in Reference [5].

Table 1 — Example of a probe suitable for sampling fire gases from the door of the ISO 9705 room

Probe characteristics[a]	
Hole number	**Hole diameter** mm
1 (closest to end)	5
2	3,2
3	2,5
4	2,1
5	1,8
6	1,6
7 (closest to pump)	1,5

[a] This probe has an internal diameter of 6 mm and the holes are placed 10 cm apart. The end of the probe is sealed.

This probe is placed such that it crosses the top of the door opening with the lowermost hole, 30 cm below the top of the door. The holes are facing downstream from the fire gases.

5.3 Filter

A heated filter shall be placed directly after the probe to remove soot and other particulates.

NOTE 1 This is necessary as soot, otherwise, might accumulate in the sampling tubing and obstruct the sampling flow. It is further necessary to remove any particulates before entering the gas cell where mirrors and windows can become contaminated with a reduced optical throughput of the instrument as a result.

The type of filter recommended is a high capacity cylindrical filter.

NOTE 2 The choice of filter porosity and filter area is often a compromise. A fine porosity gives a high degree of soot removal but often leads to relatively fast blocking of the filter. A large filter area increases the capacity of the filter but can increase losses of e.g. HCl in the filter (possibly due to insufficient heating of the larger filter or due to the faster saturation behaviour of a smaller filter).

NOTE 3 Details on the selection of filters are given in ISO 19702.

The filter characteristics shall be reported (see Clause 9).

The filter housing shall be heated to at least 150 °C (the maximum is 190 °C).

The filters shall be analysed for the presence of acid gases if these are to be measured and losses in the filter can be expected.

NOTE 4 ISO 19702 provides information for the analysis procedure.

5.4 Tubing

Tubing for transportation of the sampled gas to the gas cell of the FTIR shall be made of a non-reactive heat resistant material.

Sampling tubing made of PTFE with an internal diameter of 3 mm to 4 mm is suitable. The length shall be kept as short as practically possible (by preference less than 3 m but lengths of up to 10 m can be needed in some installations).

The tubing shall be maintained at a constant temperature of at least 150 °C (the maximum is 190 °C).

If long sampling lines (longer than 3 m) are used, a consequence analysis should be done and information on the increase of delay time should be given in the report.

NOTE 3 If there are hot spots in the sampling system, PTFE can distort. ISO 19702 provides more information.

5.5 Pump

The pump shall transport the sampled gases through the FTIR gas cell preferable at a constant volume flow rate during the fire test. The required volume flow rate depends on the volume of the gas cell and of the desired time resolution of the measurement.

NOTE 1 The required flow rate of the combustion gases drawn into the system must be high enough to achieve the desired time to 90 percent response. This is a function of the flow rate and the internal volumes of the filters, tubing, and gas cell. See ISO 19702 for the procedure to determine response times.

The pump can be positioned before or after the FTIR gas cell.

NOTE 2 Positioning of the pump after the gas cell and letting the pump pull the gases through the cell is the most common technical solution. The advantage is that an unheated pump can be used (removal of water before the fire effluent gases entering the pump is, however, often necessary). The disadvantage is that the pressure in the gas cell can be affected by the pump.

