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Toxicity testing of fire effluents — Guidance for analysis of gases and vapours in fire effluents using FTIR gas analysis

Essais de toxicité des effluents du feu — Lignes directrices pour l'analyse des gaz et des vapeurs dans les effluents du feu par spectroscopie infrarouge à transformée de Fourier (IRTF)

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Foreword

ISO (the International Organization for Standardization) is a worldwide 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19702 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 3, *Fire threat to people and environment*.

This corrected version of ISO 19702 incorporates the following corrections:

— 5.2.2.1: subclauses, which were numbered 4.2.2.1.1 to 4.2.2.1.4, have been renumbered to 5.2.2.1.1 to 5.2.2.1.4, respectively;

— Annex A, paragraph before Figure A.2, fourth sentence: "A coil of 0,6 cm (¼ in) od tubing..." has been changed to "A coil of 0,6 cm (¼ in) outside diameter (OD) tubing...";

— Bibliography: The number of reference [4] reference has been changed from ISO/CD 21489 to ISO 21489.

— Bibliography: The number and title of reference [5] have been modified to the following:

> IEC/TS 60695-7-50, *Fire hazard testing — Part 7-50: Toxicity of fire effluent — Estimation of toxic potency — Apparatus and method*

Introduction

During recent years, analytical techniques have been used widely for the measurement of the concentrations of specific volatiles generated during both laboratory studies and real fires.

The analysis of gases in fire effluents, whilst occasionally needing to rely on methods perfected in other fields (e.g. atmospheric pollution), represents a very specialized field of study due to the complexity and reactivity of the gas mixtures and the possibility for a rapid change in concentration with time. This has led a number of scientists from different countries developing new, or adapting existing methods for the analysis of the gases present during combustion, in accordance with their own requirements.

In some cases, common lines of analysis have emerged, and there is now sufficient expertise and experience to define standard methods for analysing selected gases. Much of this information is provided in ISO 19701, which presents a variety of chemical methods for the determination of individual gases of toxicological importance. Typically, multiple methods are needed to determine all the species of interest for fire hazard analysis.

Fourier transform infrared (FTIR) spectroscopy is different from other techniques in that

— a single method can be used to determine a variety of gases;

— FTIR measurements can be time-resolved, enabling the monitoring of how species develop throughout the fire;

— if a new toxicant should later be identified as important, relevant data concerning the presence of that toxicant might be found in the stored FTIR spectra from previous experiments.

ISO/TC 92 SC 3 has therefore developed ISO 19702 as a separate document.

There are two distinct ways in which FTIR has been used to characterize fire effluent:

— open path analysis, in which the infrared beam is directed across the effluent within the test apparatus;

— extractive analysis, in which a fraction of the apparatus environment is continuously flowed to a sample cell for remote measurement (e.g. IMO resolution MSC 61(67), part 2 toxicity analysis).

Fire scientists have successfully applied variants of both approaches; although, the latter is the more common.

In particular, a European Union funded project (SAFIR) focused on the testing and validation of an extractive FTIR method for use in fire testing. The results of this project form the basis for ISO 19702.

In this International Standard, specific recommendations for sampling systems for use in small-scale and large-scale measurements, for spectral resolution, and for collection and use of calibration spectra are provided. Spectral information is provided for the gases studied specifically in the SAFIR project as an aid to users to determine spectral regions of interest. Finally, applications of the analytical method are discussed.

The primary purpose of the analytical method presented here is to measure the concentration of toxic species to aid in

a) characterizing physical fire models;

b) validating numerical fire models;

c) setting the conditions for exposure in biological studies;

d) monitoring of biological studies;

e) interpreting biological studies;

f) providing data for use in combustion toxicity assessment without requiring biological studies.

The methods are also generally applicable to the analysis of fire effluents in many situations including real fires.

Any chemical analysis is selective.

Chemical analytical methods are usually appropriate for accurate determination of some species, less for others. Thus, multiple methods can be needed to determine all the species of interest.

In most cases, FTIR can provide the concentration data needed to calculate the yields of the chemical species that are important as input to toxic hazard assessment.

The general recommendations given are based on work conducted using a number of small- and large-scale standard test methods. It is important that this International Standard be read together with the following standards:

— ISO 9705;

— ISO 5660-1:2002;

— ISO/CD 21489:—;

— IEC 60695-7;

— EN 13823:2002;

— ISO 5725.

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1 Scope

This International Standard specifies methods for the individual analysis of airborne concentrations of carbon monoxide (CO), carbon dioxide (CO_2), hydrogen cyanide (HCN), hydrogen chloride (HCl), hydrogen bromide (HBr), nitric oxide (NO), nitrogen dioxide (NO_2), and acrolein (CH_2CHCHO). Although not specifically defined in this International Standard, as they were not specifically studied in the SAFIR project, the method presented is suitable for most gaseous species able to be analysed using the FTIR technique, including hydrogen fluoride (HF) and sulfur dioxide (SO_2).

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.

ISO 5660-1:2002, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement and results*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
spectrometer
instrument used to disperse radiant energy into a spectrum and measure certain properties such as wavelength, mass, energy, or index of refraction

3.2
spectroscopy
study of spectra, especially to determine the chemical composition of substances and the physical properties or concentration of molecules, ions, and atoms

3.3
Fourier transform Infra-red spectroscopy
FTIR
technique for measuring concentrations of multiple species simultaneously using the mathematics of Fourier transforms

3.4
resolution
full width at half height of the instrument line shape function

NOTE This is expressed in units of per centimetre and is the smallest spacing between absorption peaks that can be resolved.