
**Generation and analysis of toxic gases
in fire — Calculation of species yields,
equivalence ratios and combustion
efficiency in experimental fires**

*Production et analyse des gaz toxiques dans le feu — Calcul des taux
de production des espèces, des rapports d'équivalence et de l'efficacité
de combustion dans les feux expérimentaux*

iteh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 19703:2018

<https://standards.iteh.ai/catalog/standards/iso/3fc0c688-5858-4a6d-8a5b-84289cca603c/iso-19703-2018>



iTeh Standards
(<https://standards.iteh.ai>)
Document Preview

ISO 19703:2018

<https://standards.iteh.ai/catalog/standards/iso/3fc0c688-5858-4a6d-8a5b-84289cca603c/iso-19703-2018>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Symbols and units	3
5 Appropriate input data required for calculations	4
5.1 Data handling	4
5.1.1 Uncertainty	4
5.1.2 Significant figures and rounding off	5
5.2 Test specimen information	5
5.2.1 Composition	5
5.2.2 Net heat of combustion	5
5.3 Fire conditions	5
5.3.1 Apparatus	5
5.3.2 Set-up procedure	5
5.4 Data collection	6
5.4.1 Data acquisition	6
5.4.2 Measured data and observations	6
6 Calculation of yields of fire gases and smoke, stoichiometric oxygen-to-fuel mass ratio and recovery of key elements	6
6.1 Calculation of measured yields from fire gas concentration data	6
6.2 Calculation of notional gas yields	9
6.2.1 General	9
6.2.2 From the elemental composition	9
6.2.3 From the empirical formula	10
6.3 Calculation of recovery of elements in key products	11
6.4 Calculation of stoichiometric oxygen-to-fuel mass ratio	11
6.4.1 General	11
6.4.2 From the chemical equation for complete combustion	11
6.4.3 From the net heat of combustion, ΔH_c	13
6.4.4 From the carbon content of the material	14
6.5 Calculation of smoke yields	19
6.5.1 General	19
6.5.2 Smoke yields based on mass of smoke particulates	19
6.5.3 Smoke yields based on light obscuring properties	19
6.5.4 Relationship between mass measurement and light obscuration	21
7 Calculation of equivalence ratio	21
7.1 General	21
7.2 Derivation of ϕ for flow-through, steady-state experimental systems	23
7.3 Derivation of ϕ for flow-through, calorimeter experimental systems	24
7.4 Derivation of ϕ for closed chamber systems	24
7.5 Derivation of ϕ in room fire tests	25
8 Calculation of combustion efficiency	25
8.1 General	25
8.2 Heat release efficiency	26
8.3 Oxygen consumption efficiency	26
8.3.1 General	26
8.3.2 Oxygen depletion method	26
8.3.3 Oxygen-in-products method	27
8.4 Oxides of carbon method	28

iTeh Standards
(<https://standards.itih.ai>)
Document Preview

ISO 19703:2018

<https://standards.itih.ai/catalog/standards/iso/3fc0c688-5858-4a6d-8a5b-84289cca603c/iso-19703-2018>

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 19703:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

- redundant symbols have been deleted;
- missing symbols have been added;
- units of some symbols in formulae and tables have been corrected to conform with the ISO/IEC Directives, Part 2;
- unnecessary formulae have been deleted;
- mistakes in formulae have been corrected.

Introduction

It is the view of committees ISO TC 92/SC 3, ISO TC 92/SC 4, and IEC TC 89 that commercial products should not be regulated solely on the basis of the toxic potency of the effluent produced when the product is combusted in a bench-scale test apparatus (physical fire model). Rather, the information that characterizes the toxic potency of the effluent should be used in a fire risk or hazard assessment that includes the other factors that contribute to determining the magnitude and impact of the effluent. It is intended that the characterization of

- a) the apparatus used to generate the effluent, and
- b) the effluent itself

be in a form usable in such a fire safety assessment.

As described in ISO 13571, the time to incapacitation in a fire is determined by the integrated exposure of a person to the fire effluent components. The toxic species concentrations depend on both the yields originally generated and the successive dilution in air. The former are commonly obtained using a bench-scale apparatus (in which a specimen from a commercial product is burned) or a real-scale fire test of the commercial product. These yields, expressed as the mass of effluent component per mass of fuel consumed, are then inserted into a fluid mechanical model which estimates the rate of fuel consumption, transport and dilution of the effluent throughout the building as the fire evolves.

For the engineering analysis to produce accurate results, it is preferred that the yield data come from an apparatus that has been demonstrated to produce yields comparable to those produced when the full product is burned. In addition to depending on the chemical composition, conformation and physical properties of the test specimen, toxic-product yields are sensitive to the combustion conditions in the apparatus. Thus, one means of increasing the likelihood that the yields from a bench-scale apparatus are accurate is to operate it under combustion conditions similar to those expected when the real product burns. As described in ISO 19706, the important conditions include whether the fuel is flaming or non-flaming, the degree of flame extension, the fuel/air equivalence ratio and the thermal environment. Similarly, these parameters should be known for a real-scale fire test.

The yields of toxic gases, the combustion efficiency and the equivalence ratio are likely to be sensitive to the manner in which the test specimen is sampled from the whole commercial product. There can be difficulty or alternative ways of obtaining a proper test specimen. That is not the subject of this document, which presumes that a specimen has been selected for study and characterizes the combustion conditions and the yields of effluent species for that specimen.

For those experimental fires in which time-resolved data are available, the methods in this document should be used to produce either instantaneous or averaged values. The application can be influenced by changes in the chemistry of the test specimen during combustion. For those fire tests limited to producing time-averaged gas concentrations, the calculated values produced by the methods in this document are limited to being averages as well. In real fires, combustion conditions, the fuel chemistry and the composition of fire effluent from many common materials and products vary continuously during the course of the fire. Thus, how well the average yields obtained using these methods correspond to the yields in a given real fire has much to do with the stage of the fire, the pace of fire development and the chemical nature of the materials and products exposed.

This document provides definitions and equations for the calculation of toxic product yields and the fire conditions under which they have been derived in terms of equivalence ratio and combustion efficiency. Sample calculations for practical cases are provided.