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BASIC SAFETY PUBLICATION

Fire hazard testing – Part 11-40: Test flames – Confirmatory tests – Guidance

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FOREWORD

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IEC TS 60695-11-40 has been prepared by IEC technical committee 89: Fire hazard testing. It is a Technical Specification.

It has the status of a basic safety publication in accordance with IEC Guide 104 and ISO/IEC Guide 51.

The text of this Technical Specification is based on the following documents:

DTS	Report on voting
89/1498/DTS	89/1512/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) former Clause 4 split into updated/rearranged new Clause 4 and Clause 5;
b) Table 1 updated and moved to new Clause 4;
c) former Clause 5 transformed to Clause 6;
d) former Clause 6 transformed to Clause 7;
e) former Clause7, Clause 8 and Clause 9 combined into an updated/rearranged new Annex A; and
f) all figures were updated.

This Technical Specification is to be used in conjunction with IEC 60695-11-2, IEC 60695-11-3, IEC 60695-11-4 and IEC 60695-11-5.

A list of all the parts in the IEC 60695 series, under the general title *Fire hazard testing*, can be found on the IEC website.

Part 11 consists of the following parts:

Part 11-2: Test flames – 1 kW nominal pre-mixed flame – Apparatus, confirmatory test arrangement and guidance

Part 11-3: Test flames – 500 W flames – Apparatus and confirmational test methods

Part 11-4: Test flames – 50 W flame – Apparatus and confirmational test method

Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance

Part 11-10: Test flames – 50 W horizontal and vertical flame test methods

Part 11-11: Test flames – Determination of the characteristic heat flux for ignition from a non-contacting flame source

Part 11-20: Test flames – 500 W flame test methods

Part 11-30: Test flames – History and development from 1979 to 1999

Part 11-40: Test flames – Confirmatory tests – Guidance

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Standard flames are specified for various small-scale fire tests. Apparatus design and test parameters are specified in an effort to ensure consistent and defined flames. Burner designs, material specifications and fuel and air specifications are typical necessary parameters. Experience has shown that the quality of the flames and the resulting test measurements are influenced significantly by subtle variations in the equipment and test technique. Simple checks on flame qualities, such as flame colour and dimensions, or the melting characteristics of silver wire, are also sometimes specified or recommended.

The need for a relatively simple check on the power of a flame has been recognized, leading to the introduction of confirmatory tests based on copper block calorimetry. This document is intended to provide information and guidance about small-scale standard flames and the various copper block confirmatory tests.

FIRE HAZARD TESTING –

Part 11-40: Test flames – Confirmatory tests – Guidance

1 Scope

This part of IEC 60695, which is a Technical Specification, presents a general characterization of small-scale test flames and associated confirmatory tests based on copper block calorimetry. Guidance is presented for the selection of critical parameters in confirmatory test designs.

NOTE A theory of thermal dynamics presents, in Annex A, additional performance parameters for confirmatory tests, enabling a precise implicit mathematical characterization of confirmatory test heating curves.

This basic safety publication is intended for use by technical committee in the preparation of safety publications in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. The requirements, test methods or test conditions of this basic safety publication will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60695-4:2012, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

IEC 60695-11-2, *Fire hazard testing – Part 11-2: Test flames – 1 kW pre-mixed flame – Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-3, *Fire hazard testing – Part 11-3: Test flames – 500 W flames – Apparatus and confirmational test methods*

IEC 60695-11-4, *Fire hazard testing – Part 11-4: Test flames – 50 W flame – Apparatus and confirmational test method*

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

ISO 13943:2017, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60695-4 and ISO 13943 (some of which are reproduced below), and the following, apply.

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
confirmatory test
calorimetric procedure intended as a diagnostic indicator to reveal anomalous behaviour or conditions in a test flame, burner or associated hardware

[SOURCE: IEC 60695-4:2012, 3.2.4]

3.2
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

Note 1 to entry: A qualitative example is a space in which a wax candle flame remains essentially undisturbed. Quantitative examples are small-scale fire tests in which a maximum air speed of 0,1 $m.s^{-1}$ or 0,2 $m.s^{-1}$ is sometimes specified.

[SOURCE: ISO 13943:2017, 3.83]

3.3
diffusion flame
flame in which combustion occurs in a zone where the fuel and the oxidizing agent mix, having been initially separate

Note 1 to entry: Compare with the term pre-mixed flame (3.5).

[SOURCE: ISO 13943:2017, 3.82]

3.4
flame stabilizer
assembly normally fitted to the top of a standard laboratory Bunsen or Tirrill burner intended to mitigate the destabilizing effect of the turbulent mixing of flame gases with the ambient air, by providing an intervening layer of gas having an intermediate velocity between the ambient still air and the faster flame gases

[SOURCE: ISO 13943:2017, 3.173]

3.5
pre-mixed flame
flame in which combustion occurs in an intimate mixture of fuel and oxidizing agent

Note 1 to entry: Compare with the term diffusion flame (3.3).

[SOURCE: ISO 13943:2017, 3.307]

3.6
small-scale fire test
fire test performed on a test specimen of small dimensions

Note 1 to entry: There is no clear upper limit for the dimensions of the test specimen in a small-scale fire test. In some instances, a fire test performed on a test specimen with a maximum dimension of less than 1 m is called a small-scale fire test. However, a fire test performed on a test specimen of which the maximum dimension is between 0,5 m and 1,0 m is often called a medium-scale fire test.

[SOURCE: ISO 13943:2017, 3.346]

3.7
Venturi effect
reduction in pressure as a result of the increase in velocity of a fluid when it passes through a constriction in a pipe

4 Test flames

4.1 General

Flames consist of chemically exothermic reacting gaseous mixtures of oxidizer (typically oxygen or air mixture) and reducer or fuel (typically fuel gas or vapour). For standardized test flames, suitable hardware with supplies of combustible materials (i.e. fuel gas) delivers a continuous flow of the needed gaseous reactants to maintain the desired standardized flame. There are two types of test flames, as follows.

4.2 Diffusion flames

Diffusion flames are produced by a simple flow of fuel gases that combust at the point of mixing with air at the exit orifice of the hardware (e.g. the outlet of the burner tube). The advantages of diffusion flames are the simplicity of the hardware (often a simple tube), and the better simulation of actual flames likely to be encountered in equipment. The disadvantage is that they are geometrically less stable.

4.3 Pre-mixed flames

Pre-mixed flames are produced by mixing a part of the combustion air with the fuel gas prior to the combustion point at the outlet of the burner tube. The remaining part of the combustion air is provided in a similar way as with diffusion flames. The resulting flame has an inner/lower cone that is typically a lighter blue colour consisting of the pre-mixed gas and air mixture with excess fuel gas, and an outer/upper cone that is typically a very faint darker blue colour where the remaining needed additional air diffuses into this upper portion of the flame. The inner/lower cone is at a much lower temperature and is chemically reducing, while the outer/upper part of the flame is much hotter and more oxidizing.

Pre-mixed gases enter the stabilized flame at the upper end of the burner tube. Pre-mixed flames have the advantage of higher efficiency and higher flame temperature, and allow the metering of combustion air as well as fuel gas, but require much more complex hardware than used to produce diffusion flames. The combustion air in pre-mixed burners can be either directly metered or provided through an adjustable open shutter assembly using the Venturi effect.

4.4 Standardized test flames

Table 1 lists the standard test flames described in the IEC 60695 standard series.

Table 1 – Standardized test flames with confirmatory tests

IEC 60695 part No.	Nominal flame power	Flame type[a]	Gas purity	Typical overall flame height	Typical flame cone height	Copper block mass	Copper block height above burner	Time for copper block to increase in temperature from 100 °C to 700 °C
	W		%	mm	mm	g	mm	s
11-2	1 000	P,pre	≥ 95	178 ± 30	62 ± 16	10 ± 0,05	95 ± 1	46 ± 6
11-3 Method A	500	M, pre	≥ 98	approx. 125	approx. 40	10 ± 0,05	55 ± 1	54 ± 2
11-3 Method C	500	M or P, pre	≥ 98	approx. 125	approx. 40	10 ± 0,05	55 ± 1	54 ± 2
11-4	50	M, pre	≥ 98	20 ± 2	-	1,76 ± 0,01	10 ± 1	44 ± 2
11-5	[b]	P or B, dif	≥ 95	12 ± 1	-	0,58 ± 0,01	6,0 ± 0,5	23,5 ± 1,0

[a] M = methane, P = propane, B = butane, dif = diffusion, pre = pre-mixed.

[b] Assessments of the power of the needle flame vary. With butane, values of 49,75 W and 37,8 W have been calculated; with propane, a value of 40,4 W has been calculated.

4.5 Critical parameters

The most important parameters to be specified for the production of a standard flame are the design of the burner and the fuel gas and air flows.

In order to increase the accuracy of the measurement of fuel gas and air flows, it is recommended that mass flow meters are used.

The size of the flame should be used only for guidance. This is because different individuals have differing sensitivities to visible light, particularly at the blue end of the spectrum. Flame height is therefore a subjective judgement.

The confirmatory test is used to check that nothing is fundamentally incorrect with the apparatus and set-up – see 7.5.

5 Burners and fuel gases

5.1 Diffusion flame burners

A diffusion flame burner usually consists of a burner tube (e.g. a straight metal tube with a round cross-section) and a gas flow control valve. IEC 60695-11-5 specifies a diffusion flame burner.

5.2 Pre-mixed burners

5.2.1 Metered air pre-mixed burners

The design of pre-mixed burners provides for the control of both air and fuel gas. Both can be introduced through specified orifices with specified flow rates and back pressures. Normally, an extra manifold assembly is used for the metered air and the restrictive fuel gas orifice is still necessary to produce a high gas stream flow rate for proper mixing. Having both metered air as well as fuel gas will provide much better control of the resulting standardized flames. Mass flow meter are recommended to control air and the fuel gas.