TECHNICAL SPECIFICATION

ISO/TS 19850

First edition
2022-05

Fire tests — Use of LED (light-emitting diode) as an alternative to white light for measuring smoke parameters

Reference number
ISO/TS 19850:2022(E)

Contents

Page

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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 1, *Fire initiation and growth.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Traditional white light bulbs including tungsten incandescent lamps, used until now for smoke density measurements in fire tests, are no longer available. Methods therefore need to be developed for their replacement with LED (light-emitting diode) light sources. This document is intended to provide guidance on replacing the light source in a smoke density measurement with an LED light source.

Fire tests — Use of LED (light-emitting diode) as an alternative to white light for measuring smoke parameters

1 Scope

This document specifies methodologies for comparing the smoke density and the smoke production rate during fire tests measured by LED (light-emitting diode) with those measured by white light. These methodologies are intended for the identification of suitable LEDs which can be used as alternatives to white light sources.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke, under specified conditions

3.2
optical density of smoke
measure of the attenuation of a light beam passing through smoke expressed as the logarithm to the base 10 of the opacity of smoke

3.3
transmittance
ratio of transmitted light intensity through smoke to incident light intensity, under specified conditions

3.4
smoke
visible part of fire effluent

3.5
smoke production
amount of smoke that is produced in a fire or fire test

3.6
smoke production rate
amount of smoke produced per unit of time in a fire or fire test

4 Symbols and units

For the purposes of this document, the symbols and units shown in Table 1 apply.

Table 1 — Symbols and their designations and units

Symbol	Definition	Unit
D	degree of freedom	1
d	optical density	1
I_j	light transmission at time, t_j	1
I_{LED}	measurement of light transmission for LED	1
I_{WH}	measurement of light transmission for white light	1
N	normal distribution	1
n	sample size	-
s_{LED}	relative spectral distribution of a LED light	1
s_{Lamp}	relative spectral distribution of a white light	1
t_x	time at point x	s
t_{crit}	critical point (time)	s
V_{d}	variance	1
Δp	pressure difference on the measurement section	Pa
λ	wavelength	nm
σ	standard deviation	1

5 Principle

White light systems are currently used in several documents, for example, ISO 9239-1, ISO 9705-1, ISO 24473, IEC 61034-1, EN 13823 and EN 50399.

This document explains how the abovementioned standards can be amended based on the following comparisons in order to confirm that a given replacement light source is suitable:

1) comparison of light source spectra, as described in Clause 8;

2) comparison of apparatus (ISO 9705-1, ISO 24473, ISO 9239-1and EN 13823), as described in Clause 9;

NOTE There are two different methods described in Clause 9: method A (which is the preferred method) and method B.

3) comparison in an alternative experimental set-up specially designed for this purpose, as described in Clause 11.

6 Overview of smoke measurement used in existing light extinction test methods

6.1 General

The white light smoke measurement system used in ISO 9239-1, ISO 9705-1 and ISO 24473, for example, consists of a light-emitting system and a receiver with a lens system in between. All parts are described in ISO 3182 and to some extent in each of the mentioned standards.

The light source is a gas-filled tungsten incandescent lamp. There are some small differences in colour temperature between the different apparatuses. A lens system is fitted to make a (nearly) parallel light beam with a diameter of 20 mm or 25 mm.

The detector has a spectral responsivity agreeing with the CIE photopic curve. It can be a silicon photo diode at least 7 mm^2 with a spectral filter set in front for adjusting the responsivity to fit the CIE photopic curve.

The receiver system is the same as prescribed in ISO 9239-1, for example.

6.2 Light-receiving system

All the light-receiving systems conform to ISO 3182, regardless of light source bulb in the light source system.

The light-receiving system shall consist of an achromatic system of lenses and a silicon photo-electric diode in front of which a spectral filter is located to accommodate the human eye luminosity function on viewing in daylight (Figure A.1).

6.3 Measuring device

The measuring device conforms to ISO 3182.

The measuring device is fitted with an amplifier that can be tuned to display the voltage of the photo-electric diode as a percentage of the initial value (transmission). The accuracy of the display is within ±1,5 % of the final value. There is a means for outputting the measured values for external recording.

In order to simplify evaluation of the measurements, the instrument may have a logarithmic output to allow the optical density to be recorded externally.

6.4 Neutral density filter comparison

The calibration procedure conforms to EN 50399.

The following steps are performed with the measuring equipment operating.

a) Place a light-blocking insert into the filter holder and adjust to 0.

b) Remove the light-blocking insert and adjust the signal from the light receiver to 100 %.

c) Start the time measurement and record the signal from the light receiver for a period of two minutes.

d) Introduce one of the following filters and record the corresponding signal for at least one minute where the filters to be used are with optical density, *d*, 0,04 - 0,1 - 0,3 - 0,5 - 0,8 - 1,0 and 2,0.

e) Repeat step d) for the other filters.

f) Stop the data acquisition and calculate the mean transmission values for all filters.

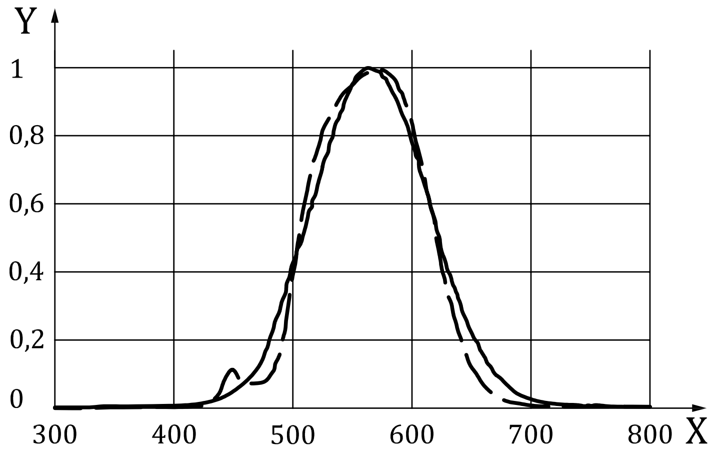
Each *d*-value calculated from the mean transmission value [$d = -\lg(I)$] should be within ±5 % or ±0,01 of the theoretical *d*-value of the filter, whichever is the greater.

7 LED light sources

LED sources that are considered as replacement candidates for the white light system should provide a continuous light spectra. The illumination reaching the detector side should be powerful enough to have a similar signal output as measured with the white light source (i.e. the strength of the light from the LED falling on the detector is similar to the white light). The light source shall be stable within ±0,5 % including temperature, for short- and long-term duration. The power source shall be adapted to ensure this.

8 Comparison of spectra from different light sources

Various LEDs exist with different colour and spectral distributions. Considering the purpose of light attenuation for smoke density measurement, it is necessary to understand the spectral distribution of the tested LED. Figure 1 shows an example of spectral distribution of an LED (white) compared with that of white light.



Key

X spectra (nm)

Y light intensity (-)

—— white light

— — white LED

Figure 1 — Example of spectral distribution of white light and LED (white)

If the spectrum of the LED light is known as exemplified in Figure 1 then the potential for the LED evaluated can be determined by comparing the spectra of the LED and the old white light system over the range of wavelengths (320 ~ 1 100 nm) to which the detector is sensitive. The comparison is conducted by multiplying the spectra with the sensitivity curve of the detector and then integrating over the wavelength range, as shown in Formulae (1) and (2):

$$\int_{320}^{1\,100} s_{\text{LED}} \times d\lambda \tag{1}$$

$$\int_{320}^{1\,100} s_{\text{Lamp}} \times d\lambda \tag{2}$$

The difference in the integral shall be less than 5 %, as expressed in Formula (3):

$$\left| \int_{320}^{1\,100} s_{\text{LED}} \times d\lambda - \int_{320}^{1\,100} s_{\text{Lamp}} \times d\lambda \right| / \int_{320}^{1\,100} s_{\text{Lamp}} \times d\lambda < 0{,}05 \tag{3}$$

For example, in case of Figure 1, compared to the integral value of white light as standard, the integral value of white LED is 2,89 % less.

9 Method of measurement in each apparatus where the white light system is originally installed

9.1 General

In this clause, the method of comparing the transmission values of both the original white light and the new light source (LED) is described in relation to each standardized test method. As the smoke production rate and the smoke density are calculated based on the transmission values, the comparison procedures in this clause are primarily focused only on the light transmission.

There are two methods for installing the new light source (LED) to the duct: method A (the preferred method) and method B. In method A, both the new light source (LED) and the receiver are installed in the proximity of the original white light system. The advantage of this method of installing the new light source (LED) is that it is possible to measure the transmission of two different light systems at the same time with the same smoke. On the other hand, the disadvantage is that it is necessary to make this new arrangement in the duct.

In method A the additional system should be placed a defined distance away from the original white light system. The distance shall be sufficient for avoiding any influence on the original white light system. A distance of one duct diameter is generally sufficient. This needs to be checked by turning on only one of the lights to see if it reaches the other detector. However, it is important to ensure that the additional system does not influence the flow profile or the measurements of the other parameters such as flow measurement and gas analysis. The additional system should also not be too close to bends in the duct or subject to other flow profile changes.

In method B, the original light source (white light) is replaced by the new light source (LED). The advantage of this method is that it is not necessary to make a new arrangement in the duct. On the other hand, the disadvantage is that it is impossible to measure the transmission of the two light systems at the same time. It is possible to remove this disadvantage by using repeatable test fire sources on each occasion. This means that the repeatability of smoke generation should be carefully considered in method B. Therefore, it is recommended to use method A wherever possible. If the situation does not always permit the additional installation of a new light source in the duct because of restrictions in the apparatus or laboratory environment, etc., then method B can be used as an alternative. In the case of ISO 9239-1, it is only possible to use method B.

Information on suitable test fire sources is given in Clause 10, and according to that information, three or more kinds of fire sources should be used for each test apparatus. For method A, two tests are performed with each fire source (six tests in total), while for method B, three tests are performed with each fire source and with each light source, resulting in eighteen tests in total.

9.2 Comparison between the original white light and the new LED in ISO 9705-1

9.2.1 General

In this example, both method A and method B could be applied. The exhaust system of ISO 9705-1 is shown in Figure 2.