SLOVENSKI STANDARD
SIST EN 50399:2011

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Skupne preskusne metode za ognjevzdržnost kablov - Meritve oddajanja toplote in nastajanja dima na kablih med preskusom z razpršenim plamenom - Preskusna naprava, postopki, rezultati

Common test methods for cables under fire conditions - Heat release and smoke production measurement on cables during flame spread test - Test apparatus, procedures, results

Allgemeine Prüfverfahren für das Verhalten von Kabeln und isolierten Leitungen im Brandfall - Messung der Wärmefreisetzung und Raucherzeugung während der Prüfung der Flammenausbreitung - Prüfeinrichtung, Prüfverfahren und Prüfergebnis

Méthodes d'essai communes aux câbles soumis au feu - Mesure de la chaleur et de la fumée dégagées par les câbles au cours de l'essai de propagation de la flamme - Appareillage d'essai, procédure et résultats

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Common test methods for cables under fire conditions - Heat release and smoke production measurement on cables during flame spread test - Test apparatus, procedures, results

Méthodes d'essai communes aux câbles soumis au feu -
Mesure de la chaleur et de la fumée dégagées par les câbles au cours de l'essai de propagation de la flamme -
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CENELEC

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 20, Electric cables.

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Introduction

EN 50399 specifies the test apparatus and test procedures for the assessment of the reaction to fire performance of cables to enable classification under the Construction Products Directive [1] to be achieved.

The test method describes an intermediate scale fire test of multiple cables mounted on a vertical cable ladder and is carried out with a specified ignition source to evaluate the burning behaviour of such cables and enable a direct declaration of performance. The test provides data for the early stages of a cable fire from ignition of cables. It addresses the hazard of propagation of flames along the cable, the potential, by the measurement of the heat release rate, for the fire to affect areas adjacent to the compartment of origin, and the hazard, by the measurement of production of light obstructing smoke, of reduced visibility in the room of origin and surrounding enclosures.

The following parameters may be determined under defined conditions during the test:

a) flame spread;

b) heat release rate;

c) total heat release;

d) smoke production rate;

e) total smoke production;

f) fire growth rate index;

g) occurrence of flaming droplets/particles .

The apparatus is based upon that of EN 60332-3-10 but with additional instrumentation to measure heat release and smoke production during the test. It has been demonstrated [3] that the utilisation of these additional measurement techniques, proven for other standard tests, e.g. for building products, are appropriate for assessing the reaction to fire performance of electric cables. These techniques include heat release and smoke production measurements. Compared with existing test methods described in EN 60332-3-10, they enable a more comprehensive assessment system, which is both more precise and sensitive, and enables a wider range of fire performance levels.

Care should be exercised in relating the parameters measured to different safety levels in actual cable installations as the actual installed configuration of the cables may be a major determinant in the level of flame spread, heat release and smoke production occurring in an actual fire. These parameters depend upon a number of features, such as

a) the volume of combustible material exposed to the fire and to any flaming or heat which may be produced by the combustion of the cables;

b) the geometrical configuration of the cables and their relationship to an enclosure;

c) the temperature at which it is possible to ignite the gases emitted from the cables;

d) the quantity of combustible gas released from the cables for a given temperature rise;

e) the volume of air passing through the cable installation;

f) the construction of the cable, e.g. armoured or unarmoured, multi or single core.

All of the foregoing assumes that the cables are able to be ignited when involved in an external fire.

The conditions of cable mounting, including volume of material exposed and geometrical configuration of the cables on the test ladder, and volume of airflow through the chamber have been chosen to be in accordance with that required by the Commission Decision 2006/751/EC [2]. CENELEC has not been involved in the definition of these parameters. These standardised conditions provide the basis for classification but do not necessarily correspond to conditions found in a particular cable installation.

NOTE Further information on the use of standardised conditions for classification with respect to product end-use application may be found in European Commission Guidance Paper G [4].

EN 50399 gives details of the apparatus to be used in conjunction with the equipment described in EN 60332-3-10 in order to carry out the measurement of heat release and smoke production during the test. Details of the test procedures are also given.

1 Scope

EN 50399 specifies the apparatus and methods of test for the assessment of vertical flame spread, heat release, smoke production and occurrence of flaming droplets/particles of vertically-mounted bunched wires or cables, electrical or optical, under defined conditions.

NOTE For the purpose of this standard the term "electric wire or cable" covers all insulated metallic conductor cables used for the conveyance of energy or signals.

EN 50399 details the apparatus and the arrangement and calibration of the instrumentation to be installed in order to measure the heat release and the smoke production during the test. The combustion gases are collected in a hood above the test chamber and conveyed through an exhaust system, which allows the measurement of heat release rate and smoke production. Test procedures to be used for type approval testing for classification of cables in Euroclasses $B1_{ca}$, $B2_{ca}$, C_{ca} and D_{ca} are given. Cable installation on the test ladder and the volume of air passing through the chamber are in accordance with the Commission Decision 2006/751/EC [2] which is reflected in the requirements of this standard.

The apparatus described in this standard shall be used in conjunction with that described in EN 60332-3-10.

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.

EN 60332-3-10, *Tests on electric and optical fibre cables under fire conditions – Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables – Apparatus (IEC 60332-3-10)*

EN 60584-1, *Thermocouples – Part 1: Reference tables (IEC 60584-1)*

EN ISO 13943:2010, *-Fire safety – Vocabulary (ISO 13943:2008)*

ISO 3966, *Measurement of fluid flow in closed conduits – Velocity area method using Pitot static tubes*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in EN ISO 13943:2010 and the following apply.

3.1
heat release rate
HRR
thermal energy released per unit time by an item during combustion under specified conditions

3.2
total heat release
THR
integrated value of the heat release rate over a defined period

3.3
smoke production rate
SPR
smoke production per unit time

3.4
total smoke production
TSP
integrated value of the smoke production rate over a defined period

3.5
flame spread
FS
propagation of a flame front

NOTE In this standard the extent of flame spread is determined as the extent of damage measured by the onset of char.

3.6
fire growth rate index
FIGRA
highest value of the quotient between *HRR* and time

NOTE 1 In this standard *FIGRA* is expressed in W/s.

NOTE 2 Details of the calculation of *FIGRA* are given in Annex G.

3.7
flaming droplets/particles
material separating from the specimen during the test and continuing to flame for a minimum period as described in this test method

3.8
E-value
heat release per volume of oxygen consumed

4 Test apparatus

4.1 General

The test apparatus shall consist of the test chamber, standard ladder and ignition source, as described in EN 60332-3-10, with the additional features as specified in 4.2 to 4.8. Figure 1 shows a schematic diagram of the apparatus. The ignition source shall be one ribbon-type propane gas burner. The ladder shall be the standard ladder of (500 ± 5) mm width. The air supply shall be a system that blows air into the chamber at an airflow rate of (8 000 ± 400) l/min.

The additional features of the apparatus shall be capable of measuring the following parameters:

a) oxygen consumption;

b) CO_2 production;

c) volume flow in the exhaust duct;

d) smoke production.

WARNING Care should be taken in monitoring and extinguishing cable fires once the test specimen has started to propagate fire. Some specimens may have a very high capacity to generate high heat release levels that could damage the test equipment and instrumentation. It is important that testing staff are sufficiently trained in dealing with such fires and have adequate fire fighting facilities at their disposal during testing.

NOTE 1 It is recommended that indicative temperature measurements are taken through the use of thermocouples installed along the cable bunch being tested at 1,5 m and 2,5 m above the burner and at the top of the chamber or in the duct. Such measurements can give an early indication of any excessive temperature or burning condition that may require the test to be aborted in order to prevent damage to the test equipment.

All data shall be measured and recorded every 3 s. These point measurements shall be averaged over a period of 30 s for parameters relating to heat release and 60 s for parameters relating to smoke production, in order to provide the required data. The data shall be processed according to the requirements of this standard.

NOTE 2 It is necessary to produce the average measurement in order to damp the variability caused by frequent point measurement.

The additional features and their associated measurements shall allow for calculation of the following:

a) heat release (see Annex A);

   1) heat release rate (*HRR*);

   2) total heat release (*THR*);

   3) fire growth rate index (*FIGRA*);

b) smoke production (see Annex B);

   1) smoke production rate (*SPR*);

   2) total smoke production (*TSP*).

4.2 Air input

Air shall be introduced to the test chamber through a plenum box fitted directly underneath, and of approximately the same dimensions as, the air inlet aperture. The depth of the plenum box shall be (150 ± 10) mm. Air shall be blown into the plenum box from a fan through a rectangular straight section of duct of constant cross section of (300 ± 10) mm width and (80 ± 5) mm height and a minimum length of 800 mm, which shall enter from the rear of the chamber and be parallel to the floor and along the burner centre line as shown in Figure 1. The duct shall be arranged to inlet air to the plenum box through an aperture in the longest side, centred horizontally and such that the bottom of the duct shall be no greater than 10 mm above the bottom of the plenum box. A grid shall be fitted in the air inlet aperture to achieve uniform flow of the air. The grid shall be constructed of steel plate approximately 2 mm thick with holes of approximately 5 mm diameter drilled at approximately 8 mm spacing between centres.

The airflow rate shall be measured in a circular duct prior to the rectangular cross section duct. It shall be measured by a gas flow measuring device located at a straight section of the circular duct. The minimum length of straight circular section before and after the measuring device shall be selected according to the technical specification of the measuring device.

NOTE 1 A fluid flow measuring system according to either EN ISO 5167-2 (orifice plate) or EN ISO 5167-4 (Venturi tube) is recommended. Alternatively, a Pitot tube taking multiple samples across the section of the duct and averaging to account for variations across the section or a hot wire anemometer measuring at multiple positions across the section of the duct as described in Annex D may be used.

The airflow shall be set prior to a test at (8 000 ± 400) l / min and shall not be changed during the test. The airflow shall be checked throughout the test and shall not vary by more than 10 % of the set value.

NOTE 2 This information does not need to be recorded.

4.3 Hood

A hood (see Figure 2) having a truncated shape, and where the base has a minimum length of 1,50 m and a minimum width of 1,00 m, shall be centred above the outlet of the test chamber. The base of the hood shall be raised above the top of the test chamber, with the largest side of the hood parallel to the largest side of the outlet of the chamber.

NOTE 1 A gap of approximately 200 mm to 400 mm between the top of the test chamber and the base of the hood has generally been found suitable.

There shall be a chamber above the hood to allow a connection to the exhaust duct.

NOTE 2 Plates/baffles may be installed in the hood to improve mixing of the air / effluents.

The system shall be designed to collect all the combustion products leaving the test chamber through the outlet during the test. There shall be no leakage of flames or smoke. The exhaust capacity shall be at least 1 m³/s at normal pressure and a temperature of 25 °C. The exhaust system design shall not be based on natural convection.

NOTE 3 In order to extract all gases and vapours, especially in the case of heavily burning cables, or cables which require to be specially extinguished and produce high volumes of gases and vapours, an exhaust system with a capacity of 1,5 m³/s is recommended.

4.4 Exhaust duct

An exhaust duct shall be connected to the hood as described in 4.3. The inner diameter, D, of the duct shall be in the range 250 mm to 400 mm. The straight section of the duct shall have a minimum length of 12 x D, such that a uniform flow profile is established at the point of measurement.

NOTE A uniform flow profile can be obtained by introducing guide vanes (see Figure 3) before and after the measuring section such as described in EN 14390. This is highly recommended in order to obtain as precise measurements as possible.

4.5 Instrumentation in the exhaust duct

4.5.1 Volume flow

The flow shall be measured by a bidirectional probe located at the centre line of the duct and at a minimum distance from the beginning of the straight section of exhaust duct of 8 x D. The length of the straight section of duct beyond the probe shall be at least 4 x D. The probe which is shown in Figure 4 consists of a stainless steel cylinder, 32 mm long and with an outer diameter of 16 mm. The cylinder is divided into two equal chambers. The pressure difference between the two chambers shall be measured by a pressure transducer. The plot of the probe response versus the Reynolds number is shown in Figure 5 (see also Annex C).

The pressure transducer shall have a measuring precision better than ± 5 Pa. A suitable range of measurement is 0 Pa to 200 Pa (when using duct diameters between 250 mm and 400 mm).

The two connection pipes between the bidirectional probe and the pressure transducer shall be of the same length.

Gas temperature in the immediate vicinity of the probe shall be measured by a sheathed K type thermocouple with a maximum diameter of 1,5 mm in accordance with EN 60584-1. The thermocouple shall be positioned so that it does not disturb the flow pattern around the bidirectional probe.

NOTE If more than one thermocouple is used then all thermocouples shall be of the same size and type.

4.5.2 Sampling probe

The sampling probe shall be located where the exhaust duct flow is well mixed. The probe shall have a cylindrical form so that disturbance of flow is minimised. The gas samples shall be taken along the whole diameter of the exhaust duct. Examples of suitable sampling probes are shown in Figure 6. The intake of the sampling probe shall be turned downstream in order to avoid soot clogging in the probe. The sampling probe shall be connected to the gas analysers for oxygen (O_2) and carbon dioxide (CO_2) by a suitable sampling line.

4.5.3 Sampling line

The sampling line shall be manufactured from corrosion resistant material, e.g. PTFE. The combustion gases shall be filtered with inert filters to the degree of particle concentration required by the gas analysis equipment. The filtering procedure shall be carried out in more than one step. The system shall be capable of removing water vapour.

The combustion gas shall be transported by a pump which does not emit oil, grease or similar products, as these may contaminate the gas mixture.

NOTE A membrane pump is suitable.

A pump capacity between 10 l/min and 50 l/min is recommended. The pump shall generate a pressure differential of at least 10 kPa to reduce the risk of clogging of the filters by smoke.

The sampling line (see Figure 7) shall be connected at its end to O_2 and CO_2 analysers.

4.6 Extracting ventilator

At the end of the exhaust duct, an extracting ventilator shall be installed. A minimum exhaust capacity of 1,5 m³/s at normal pressure and at a temperature of 25 °C is recommended.

NOTE Legal requirements may make it necessary for equipment for collecting and washing the effluent to be fitted to the test chamber. This equipment shall be such as to collect all the effluents without causing a change in the air flow rate through the test chamber.

4.7 Smoke production measuring equipment

4.7.1 General

The optical density of the smoke can be measured by two different measuring techniques as described in 4.7.2 and 4.7.3. Although the measurement principle differs for both systems, it has been shown that the two different systems do not give substantially different results [3].

A general arrangement of an optical system is shown in Figure 8.

NOTE 1 Other systems may be used provided that their equivalence to those specified has been demonstrated.

NOTE 2 Based upon experience, white light systems are recommended.

The smoke production measuring equipment shall be located where the exhaust duct flow is well mixed.

4.7.2 White light system

A light attenuation system, of the white light type, mounted with a flexible connection to the side ducts of the exhaust duct, shall consist of the following.

a) A lamp, of the incandescent filament type operating at a colour temperature of (2 900 ± 100) K. The lamp shall be supplied with stabilized direct current, stable within 0,5 % (including temperature, short-term and long-term stability).

b) A lens system, to align the light to a parallel beam and with a diameter of at least 20 mm. The photocell aperture shall be placed at the focus of the lens in front of it and it shall have a diameter, d, chosen with regard to the focal length of the lens, f, so that d/f is less than 0,04.

c) A detector, with a spectrally distributed responsivity agreeing with the CIE V(λ) function (CIE photopic curves) to an accuracy of within ± 5 %. The detector output shall, over an output range of at least two decades, be linear within 3 % of the measured transmission value or 1 % of the absolute transmission.

Calibration of the light attenuation system shall be carried out according to E.4. The 90 % response time of the system shall be not more than 3 s.

Air may be introduced in the side ducts so that the optics stay clean, within the given light attenuation drift requirements (see E.4.2). Pressurized air can be used instead of a self suction system.

4.7.3 Laser light system

A laser photometer system shall use a helium-neon laser with a power output between 0,5 mW and 2,0 mW.

Air may be introduced in the side ducts so that the optics stay clean, within the given light attenuation drift requirements (see E.4.2). Pressurized air may be used instead of a self suction system.

NOTE The optics should be regularly inspected and cleaned from smoke deposition whenever necessary.

4.8 Combustion gas analysis equipment

4.8.1 General

The analysis of oxygen, and carbon dioxide, requires that any water vapour in the combustion gases shall be trapped by means of a suitable drying agent.

4.8.2 Oxygen

The analyser shall be of the paramagnetic type and capable of measuring a range of 16 % to 21 % oxygen (V_{O_2}/V_{air}). The noise and drift of the analyser shall be not more than 0,01 % (100 parts per million) over a period of 30 min as measured in accordance with E.2.3. The manufacturer's declared response time of the analyser shall be not more than 12 s. The output from the analyser to the data acquisition system shall have a resolution better than 0,01 % (100 parts per million).

4.8.3 Carbon dioxide

Continuous analysis of carbon dioxide shall be achieved using an IR spectrometer. The analyser shall be capable of measuring a maximum range of 0 % to 10 % carbon dioxide. The linearity of the analyser shall be 1 % of full scale or better and the manufacturer's declared response time shall be not more than 12 s.

5 Qualification of test apparatus

5.1 General

The checks in 5.2 to 5.5 shall be undertaken to qualify the apparatus.

NOTE In this document, the use of the terminology "calibration" mirrors that in EN 13823 (the SBI test). It is used in a generic way, in some cases referring to a true calibration procedure whilst in others referring to a series of checks which may, in other documents, be referred to as a verification.

5.2 Flow distribution measurements

The determination of the flow profile in the exhaust duct, in the vicinity of the probes, is required for two main reasons:

a) to check that the design of the exhaust duct gives an acceptable profile;

b) to determine a k_c which shall be compared with the k_t obtained by the following calibrations.

Further information on how to perform this measurement is given in Annex D.

NOTE The value k_c should be approximately 0,86 for a 400 mm duct.

Measurements shall be performed by means of a calibrated hot wire anemometer (or other suitable instrument) moved along a vertical axis (OY) and then along a horizontal axis (OX) to obtain the vertical and horizontal air speed distributions inside the duct.

The velocity profile shall be measured at the same airflow rate as used during the actual test (see 6.6). Measurements at additional flow settings should be made and used to demonstrate the consistency of the velocity profile determination within the range of operation.

5.3 Sampling delay time measurement

Gas analysers take a finite time to respond to changes in gas concentrations. This is called the sampling delay time. The delay times shall be determined in order to synchronise the temperature, oxygen and carbon dioxide measurements. All data shall be corrected for any delay time before calculating the heat release. The delay time of the oxygen analyser shall be determined as the time difference between a 3 K change in the duct temperature and a 0,05 % change in the oxygen concentration. The delay time of the carbon dioxide analyser shall be determined as the time difference between a 3 K change in the duct temperature and a 0,02 % change in the carbon dioxide concentration.

Sampling delay times shall be determined before commissioning the apparatus and after each major change in the gas analysis system.

5.4 Commissioning calibrations

Before initial use of the apparatus and after each major change in the gas analysis system, exhaust flow measurement, gas and airflow measurement to the burner or smoke measurement, a series of calibrations shall be performed in order to

a) check the equipment, including any improvements adopted during the set-up stage or modification period;

b) determine a commissioning k_t factor to be used for daily testing;

c) check the stability of the smoke measurement system;

d) check the correct measurement of the white light measuring system.

The calibrations shall be carried out at different levels of *HRR* covering the range of heat releases that are expected when burning cables in a test, i.e. from about 20 kW to 200 kW. This is required in order to verify the linearity of the *HRR* measurement system. Further information on the *HRR* calibration and determination of the commissioning k_t factor is given in Annex E.

The procedure given in Annex E shall be carried out and its requirements met in order to calibrate and check the smoke measuring system.

NOTE It is recommended that the commissioning calibrations are carried out at least once per year depending on the frequency of use of the equipment.

5.5 Routine calibration

5.5.1 General

Each testing day a calibration test shall be performed using the ignition source given in EN 60332-3-10. A calibration burn of at least 10 min shall be performed, using the heat output of the burner relevant to the test procedure to be used that day (i.e. 20,5 kW or 30,0 kW as appropriate). The calibration test shall be carried out without the ladder in the test chamber. The result of the calibration test shall be recorded for each testing date. Testing shall not be carried out unless the criteria given in 5.5.4 are met.

NOTE See E.2.2 and E.2.4 for the daily adjustment of the oxygen and carbon dioxide analysers

5.5.2 Procedure

The calibration shall be performed in the following sequence:

a) a 5 min base line without the burner;

b) a further 10 min with the burner at the relevant heat output;

c) a further 5 min without the burner.