SLOVENSKI STANDARD
SIST EN 50281-2-1:2000+AC:2000

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Električne naprave za uporabo ob prisotnosti gorljivega prahu - 2-1. del: Preskusne metode - Metode za ugotavljanje najnižje (ali minimalne) vžigne temperature prahu + Popravek AC

Electrical apparatus for use in the presence of combustible dust -- Part 2-1: Test methods - Methods for determining the minimum ignition temperatures of dust

Elektrische Betriebsmittel zur Verwendung in Bereichen mit brennbarem Staub -- Teil 2-1: Untersuchungsverfahren - Verfahren zur Bestimmung der Mindestzündtemperatur von Staub

Matériels électriques destinés à être utilisés en présence de poussières combustibles -- Partie 2-1: Méthodes d'essai - Méthodes de détermination de la température minimale d'inflammation de la poussière

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29.260.20	Električni aparati za eksplozivna ozračja	Electrical apparatus for explosive atmospheres

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English version

Electrical apparatus for use in the presence of combustible dust Part 2-1: Test methods - Methods for determining the minimum ignition temperatures of dust

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Partie 2-1: Méthodes d'essai
Méthodes de détermination de la température minimale d'inflammation de la poussière

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This European Standard was approved by CENELEC on 1998-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This European Standard was prepared by the Technical Committee CENELEC TC 31 Electrical apparatus for explosive atmospheres. The text of the draft was submitted to the Unique Acceptance Procedure and was approved by CENELEC EN 50281-2-1 on 1998-09-01.

This European Standard was prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and supports the essential health and safety requirements of the EC Directive 94/9/EC.

The following dates have been fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	1999-09-01
- latest date by which national standards conflicting with the EN have to be withdrawn	(dow)	1999-09-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annexes A and B are normative.

Contents

Introduction

This European Standard describes methods for determining the minimum ignition temperature of dust for the purpose of selecting electrical apparatus. These are:

- Method A: Dust layer on a heated surface at a constant temperature (clause 4);

- Method B: Dust cloud in a furnace at a constant temperature (clause 5).

Method A determines the minimum ignition temperature of a **dust layer** on a prescribed heated surface.

Method B determines the minimum ignition temperature of a **dust cloud** within a prescribed heated furnace.

The test methods are of a general nature, and may be used for purposes of comparison, but in certain industrial situations further tests may be necessary.

The methods for determining the minimum ignition temperatures are not suitable for use with recognized explosives, for example, gunpowder, dynamite, or mixtures of substances which may, under some circumstances, behave similarly.

Where there is doubt, an indication of the existence of a hazard due to explosive properties may be obtained by testing a very small quantity of the dust on a surface at 400 °C or higher, located remotely from the operator.

1 Scope

This European Standard specifies two test methods for determining the minimum ignition temperatures of dust for the purpose of selecting electrical apparatus for use in the presence of combustible dust in accordance with EN 50281-1-2:1998 and constructed in accordance with EN 50281-1-1:1998.

These methods are not suitable for use with substances having explosive properties.

Method A (clause 4) is applicable to the determination of the minimum temperature of a prescribed hot surface which will result in the decomposition and/or ignition of a layer of dust of a specified thickness deposited on it. The method is particularly relevant to industrial equipment with which dusts are present on hot surfaces in thin layers exposed to the atmosphere.

Method B (clause 5) is applicable to the determination of the minimum temperature of a prescribed hot surface which will result in the ignition of a cloud of given sample of dust or other particulate solid. The test is intended to be carried out as a complementary test after determining the minimum ignition temperature of a dust layer by method A of this European Standard.

NOTE 1 concerning method B: Because the method of operation of the furnace gives short residence times for dust particles within it, this method of test is applicable to industrial equipment where dust is present as a cloud for a short time. This method of test is of small scale and the results are not necessarily representative of all industrial conditions.

NOTE 2 concerning method B: The method is not applicable to dusts which may, over a longer period of time than provided for in the test method, produce gasses from deposits generated during pyrolysis or smouldering.

2 Normative references

EN 50281-1-1	Electrical apparatus for use in the presence of combustible dust Part 1-1: Electrical apparatus protected by enclosures - Construction and testing
EN 50281-1-2	Electrical apparatus for use in the presence of combustible dust Part 1-2: Electrical apparatus protected by enclosures - Selection, installation and maintenance
ISO 565	Test sieves - Metal wire cloth, perforated metal plate and electroformed sheet - Nominal sizes of openings
ISO 4225	Air Quality - General aspects - Vocabulary.

3 Definitions

For the purpose of this European Standard the following definitions apply:

3.1 dust: Small solid particles that settle out under their own weight but that may remain suspended in air for some time in the atmosphere (includes dust and grit as defined in ISO 4225).

3.2 ignition of a dust layer: Ignition shall be considered to have occurred if glowing or flaming is initiated in the material, or a temperature of 450 °C or more, or a temperature rise of 250 K or more above the temperature of the prescribed hot surface, is measured in the test.

3.3 minimum ignition temperature of a dust layer: The lowest temperature of a hot surface at which ignition occurs in a dust layer of specified thickness on this hot surface.

NOTE 1: Because of the wide range of processes in industry, the ignition of dust layers may be dependent upon local conditions. This method of test is not necessarily representative of all industrial conditions, where account may need to be taken of such factors as the presence of thick layers of dust and of the distribution of temperature in the environment.

NOTE 2: When carrying out this test, it is essential that all necessary precautions be taken to safeguard the health of personnel, for example, against the risk of fire, explosion, inhalation of smoke and any toxic products of combustion.

3.4 ignition of a dust cloud: The initiation of an explosion by the transfer of energy to a dust cloud in air.

3.5 ignition temperature of a dust cloud: The lowest temperature of the hot inner wall of a furnace at which ignition occurs in a dust cloud in air contained therein.

NOTE: When carrying out this test, it is essential that all necessary precautions be taken to safeguard the health of personnel, for example, against the risk of fire, explosion, inhalation of smoke and any toxic products of combustion.

4 Method A: dust layer on a heated surface at a constant temperature

4.1 Preparation of dust sample

The sample shall be prepared so as to be homogeneous and representative of the dust received for consideration.

The dust sample to be tested shall, in general, be able to pass through a woven metal wire cloth or a square hole perforated plate test sieve with a nominal size of aperture of 200 µm (supplementary sizes, ISO 565). If it is necessary to test a coarser dust, passing a test sieve with a nominal size of aperture up to 500 µm, the fact shall be stated in the report of the test.

Any apparent changes noted in the properties of the dust during preparation of the sample, for example, by sieving or owing to temperature or humidity conditions, shall be stated in the report of the test.

4.2 Test apparatus

The apparatus is shown schematically in figure A.1. Essential details and performance requirements are given in the following clauses. Methods of construction to enable these requirements to be met are described in Annex A.

4.2.1 Heated surface

The heated surface shall consist of a metal plate and shall provide a working area of at least 200 mm in diameter, and be not less than 20 mm in thickness. The plate shall be heated electrically and its temperature shall be controlled by a device for which the sensing element is a thermocouple mounted in the plate near the centre and with its junction within 1 ± 0,5 mm of the upper surface and in good thermal contact with the plate.

A similar thermocouple shall be mounted near the control thermocouple in a similar manner, and shall be connected to a temperature recorder to record the temperature of the surface during a test. The heated surface and its control device shall satisfy the following performance requirements:

a) The heated surface shall be capable of attaining a maximum temperature of 400 °C without a dust layer in position.

b) The temperature of the heated surface shall be constant to within ± 5 K throughout the period of a test.

c) When the heated surface has reached a steady state, the temperature across the surface shall be uniform to within ± 5 K when measured across two diameters at right angles, by the procedure in Annex A. This requirement shall be satisfied at nominal surface temperatures of 200 °C and 350 °C.

d) The temperature control shall be such that the recorded surface temperature does not change by more than ± 5 K during the placing of the dust layer, and it shall be restored to within ± 2 K of the previous value within 5 min of placing the dust layer.

e) Temperature control and measurement devices shall be calibrated and shall have limits of inaccuracy of ± 3 K.

4.2.2 Dust layer thermocouple

A fine thermocouple (0,20 to 0,25 mm diameter) of chromel-alumel or other suitable material shall be stretched across the heated surface, and parallel to it, at a height of between 2 mm and 3 mm from it with the junction over the centre of the plate. This thermocouple shall be connected to a temperature recorder in order to determine the behaviour of the dust layer during the test.

4.2.3 Temperature measurements

Temperature measurements using thermocouples shall be made either relative to a fixed reference junction or with automatic cold junction compensation. In either case, calibration shall satisfy the requirements of 4.2.1 e).

4.2.4 Ambient temperature measurements

The ambient temperature shall be measured by a thermometer placed not more than 1 m from the heated surface, but shielded from heat convection and radiation from the surface. The ambient temperatures shall be within the range 15 °C to 35 °C.

4.2.5 Dust layers

Dust layers shall be prepared by filling the cavity formed by placing a metal ring of appropriate height on the heated surface and leveling the layer to the top of the ring. The ring shall have an internal diameter of nominally 100 mm and shall have slots at opposite ends of a diameter to clear the test thermocouple (figure A.2). The ring shall be left in place during a test.

A given dust shall be tested in a layer of 5,0 mm ± 0,1 mm depth.

NOTE: For predictive purposes (see 4.6) a second depth (such as 12,5 mm ±0,1 mm or 15,0 mm ± 1 mm) is useful. Rings of appropriate height will be required.

4.2.6 Formation of dust layer

The dust layer shall be formed without compressing it unduly. That is to say, the dust shall be put into the ring with a spatula and distributed mainly with sideways movement of the spatula until the ring is slightly overfilled. The layer shall then be levelled by drawing a straight edge across the top of the ring. Any excess should be swept away.

For each dust, a layer shall be formed in the above manner on a sheet of paper whose weight is known and weighed. The density shall be calculated from the mass of the dust and the filled volume of the ring, and shall be reported.

4.3 Procedure

4.3.1 General

NOTE 1: The occurrence of ignition in a layer of dust on a surface at a given temperature depends critically on the balance between the rate of heat generation ("self-heating") in the layer and the rate of heat loss to the surroundings. The temperature at which ignition of a given material occurs depends, therefore, on the thickness of the layer. Values determined for two or more thickness of a given dust may be used for predictive purposes (see 4.6).

Following the recommended procedure, ignition shall be considered to have occurred if:

a) visible glowing or flaming is observed (figure 3A), or

b) a temperature of 450 °C is measured or

c) a temperature rise of 250 K above the temperature of the heated plate (figure 3C), is measured.

With regards to items b) and c) above, ignition shall not be considered to have occurred if it can be shown that the reaction does not propagate to glowing or flaming. The temperature shall be measured by thermocouple (see 4.2.2) It will usually be found that, provided the temperature of the heated surface is high enough, the temperature in the layer will slowly increase to a maximum value which may be in excess of the temperature of the heated surface and then slowly fall to a steady value below the temperature of the heated surface (figure 3B).

NOTE 2: Some materials exhibit more than one stage of self-heating, and it may sometimes be necessary to prolong the test in order to fully explore this possibility.

With organic dusts, combustion will usually take the form of charring followed by the appearance of smouldering with glowing which will progress through the layer and leave a residue of ash.

With dust layers composed of certain divided metals, ignition may be characterised by the relatively sudden appearance of highly incandescent smouldering combustion progressing rapidly through the layer.

In the determination of the minimum ignition temperature for a layer of given thickness, repeated trials shall be carried out, using a fresh layer of dust each time and with up-and-down adjustments to the temperature of the heated surface until a temperature is found which is high enough to cause ignition in the layer but which is no more than 10 K higher than a temperature which fails to cause ignition. The highest temperature at which ignition fails to occur shall be confirmed by continuing the test long enough to establish that any self-heating is decreasing in rate; that is, the temperature at the point of measurement in the layer is decreasing to a steady value lower than the temperature of the heated surface.

4.3.2 Method

The apparatus shall be set up in a position free from draughts, and preferably under a hood capable of extracting smoke and fumes.

The temperature of the heated surface shall be adjusted to the desired value and shall be allowed to become steady within the prescribed limits of 4.2.1 b). A metal ring of the required height shall be placed centrally on the heated surface and this ring shall be filled with the dust to be tested and leveled off within a period of 2 min. The recorder for the dust layer thermocouple shall then be started.

The test shall be continued until it is ascertained either that the layer has ignited, either visually or by the thermocouple record, or has self-heated without igniting and is subsequently cooling down.

If, after a period of 30 min, no self-heating is apparent the test shall be terminated and repeated at a higher temperature. If ignition or self-heating occurs the test shall be repeated at a lower temperature, if necessary, prolonging the test beyond 30 min. Testing is continued until a temperature is found which is high enough to cause ignition or self-heating in the layer, but which is no more than 10 K higher than a temperature which fails to cause ignition or self-heating.

4.3.3 Results

Tests shall be repeated with fresh layers of dust until a minimum ignition temperature has been determined. This shall be the lowest temperature, rounded down to the nearest integral multiple of 10 °C, at which ignition occurs in a layer of given thickness. Where ignition has been deemed to occur, from readings of the test thermocouple (4.3.1), the minimum ignition temperature shall be the lowest such temperature, rounded down to the nearest integral multiple of 10 °C, less 10 K.

The highest value of temperature at which ignition does not occur, or is deemed not to occur, shall also be recorded. This temperature shall not be more than 10 K lower than the minimum temperature at which ignition does occur, or is deemed to occur, and it shall be confirmed by at least three tests.

For the purposes of this European Standard, the tests shall be discontinued if ignition of a dust layer does not occur below a heated surface temperature of 400 °C. This fact shall be reported as the result of the test.

Times to obtain ignition, or times to the maximum temperature reached in the case of no ignition, shall be measured to the nearest 5 min from the time of placing the dust layer on to the heated surface, and shall be reported.

Where a dust layer fails to ignite at a temperature of less than 400 °C, the maximum duration shall be reported.

4.4 Test acceptance criteria

Results obtained by the same operator on different days and results obtained in different laboratories shall be considered unsatisfactory if they give ignition temperatures differing by more than 10 K in either case.

Where validity of test results may sometimes be poor for reasons associated with the physical nature of the dusts and the behaviour of layers during test. This shall be reported (see 4.5) and all results shall be accepted as equally valid.

The test report shall then include a brief description of the nature of the combustion following ignition, noting especially behaviour such as unusually rapid combustion or violent decomposition. Factors likely to affect the significance of the results shall also be reported; these include difficulties in the preparation of layers, distortion of layers during heating, decrepitation, melting, and evidence of flammable gas generated during heating of the dust.

4.5 Reporting of results

The test report shall include the name, source and description (if not implicit in the name) of the material tested, the date and identification of the test, the ambient temperature and the density of the material as tested (4.2.6).

The report shall state that the determination of minimum ignition temperature of the dust layer has been carried out in accordance with this European Standard.

The ignition tests shall be reported in the manner shown in the following table (showing results in descending order of surface temperature rather than in the order in which tests were performed):

Depth of (mm)	Surface temperature °C	Result of test	Time to ignition or to reach the highest layer value of temperature without ignition (min)
5	180	Ignition	16
	170	Ignition	36
	160	No ignition	40
	160	No ignition	38
	160	No ignition	42
	150	No ignition	62

NOTE: In the example given in the above table the minimum ignition temperature for the 5 mm layer would be recorded as 170 °C.

The ignition temperature shall be recorded in accordance with 4.3.3 for each depth of layer.

Tests in which the heated surface temperature differed by more than ± 20 K from the recorded minimum ignition temperature need not be reported.

4.6 Application of results

The values of minimum ignition temperature determined in accordance with method A of this European Standard apply to layers having the thicknesses used in the tests. Although for some materials it is possible to estimate the minimum temperatures of a heated surface for the ignition of layers of a given dust of intermediate or greater thickness, by linear interpolation or extrapolation of the test results plotted as the logarithm of the thickness versus the reciprocal of the minimum ignition temperature in kelvins, it is preferable to test with the required thickness.

NOTE 1: The above is the simplest predictive procedure which has some theoretical justification. More elaborate treatment based on thermal explosion theory will permit estimates for ignition of layers in other configurations, such as layers on curved surfaces. However, if it is desired to make accurate predictions for ignition under widely different conditions of exposure, in particular exposure to a symmetrical high temperature environment rather than to an unsymmetrical environment as on a hot plate, it is preferable to use results obtained for an experimental procedure matching the different environment more closely - such as ignition in an oven.

NOTE 2: When extensive prediction is intended, it is desirable to determine ignition temperatures for more than two thicknesses of layer and with an emphasis on thicker layers.