SLOVENSKI STANDARD
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Elektriļ ne naprave za uporabo v prisotnosti vnetljivega prahu - 2. del: Preskusne metode -3. oddelek: Metoda doloļ anja najniģje energije vģiga zmesi prah/zrak.

Electrical apparatus for use in the presence of combustible dust - Part 2: Test methods - Section 3: Method for determining minimum ignition energy of dust/air mixtures

Matériels électriques destinés à être utilisés en présence de poussières combustibles - Partie 2: Méthodes d'essai - Section 3: Méthode de détermination de l'énergie minimale d'inflammation des mélanges air/poussières

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Partie 2:
Méthodes d'essai –
Section 3:
Méthode de détermination de l'énergie minimale d'inflammation des mélanges air/poussières

Electrical apparatus for use in the presence of combustible dust –

Part 2:
Test methods –
Section 3: Method for determining minimum ignition energy of dust/air mixtures

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST –

Part 2: Test methods – Section 3: Method for determining minimum ignition energy of dust/air mixtures

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

International Standard IEC 1241-2-3 has been prepared by sub-committee 31H: Apparatus for use in the presence of combustible dust, of IEC technical committee 31: Electrical apparatus for explosive atmospheres.

The text of this standard is based on the following documents:

DIS	Report on voting
31H(CO)17	31H(CO)19

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

IEC 1241 consists of the following parts, under the general title: *Electrical apparatus for use in the presence of combustible dust:*

– Part 1: Electrical apparatus protected by enclosures
– Part 2: Test methods

Annexes A, B and C are for information only.

ELECTRICAL APPARATUS FOR USE IN THE PRESENCE OF COMBUSTIBLE DUST –

Part 2: Test methods – Section 3: Method for determining minimum ignition energy of dust/air mixtures

1 Scope

This section of IEC 1241-2 specifies a method of test to determine the minimum ignition energy of a dust/air mixture by an electrically generated high-voltage d.c. spark. This test method is intended to develop data to be used in deciding whether or not combustible dust/air mixtures are considered to be ignitable with respect to electrical discharge. It is intended that the dust be tested in a form (particle size, moisture content, etc.) representing conditions of actual use so that assessment of the hazard present can be made. Ignition energies determined by this method would be compared with ignition energies of other dusts to assess the relative hazard with regard to ignition by an electrical or electrostatic discharge, thereby permitting decisions to be made on the suitability of electrical apparatus for installation in areas where combustible dust is present.

The test method is not suitable for use with recognized explosives, gunpowder, dynamite, explosives which do not require oxygen for combustion; pyrophoric substances, or substances or mixtures of substances which may under some circumstances behave in a similar manner. Where any doubt exists about the existence of a hazard due to explosive properties, an indication may be obtained by placing a very small quantity of the dust in question on the heated surface of the apparatus described in section 1 of the IEC 1241-2-1, heated to 400 °C.

NOTE – Precautions should be taken to safeguard the health of personnel conducting the tests against the risk of fire, explosion and/or the effects, including toxic effects, of combustion. Compliance with this international standard does not itself confer immunity from legal obligations.

Annex B of this section includes guidance on the significance of minimum ignition energy with respect to electrostatic discharges.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 1241-2. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 1241-2 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(301, 302, 303): 1983, *International Electrotechnical Vocabulary*

- *Chapter 301: General terms on measurements in electricity*
- *Chapter 302: Electrical measuring instruments*
- *Chapter 303: Electronic measuring instruments*

ISO 4225: 1980, *Air Quality - General aspects - Vocabulary*

3 Definitions

For the purposes of this section of IEC 1241-2, the definitions in IEC 50(301, 302, 303) and also the following apply.

3.1 **dust**: Small solid particles that settle out under their own weight but that may remain suspended in air for some time.

NOTE – This definition includes what are defined in ISO 4225 as "dust" and "grit".

3.2 **combustible dust**: Dust that is ignitable in mixtures with air.

NOTES

1 Mixtures of combustible dust in air are ignitable only between certain concentration limits.

2 Combustible dusts are capable of being ignited by external ignition sources and will continue to burn at atmospheric temperatures but they will only spontaneously ignite above their minimum ignition temperatures.

3.3 **spark discharge**: Transient electric discharge which takes place between two conductors which are at different potentials. A spark is a discrete discharge that bridges the gap between the conductors in the form of a single ionization channel.

3.4 **minimum ignition energy (of a combustible dust/air mixture)**: Lowest energy of spark (as measured by the procedure in this standard) that is capable of igniting the most sensitive dust/air mixture with sustained combustion.

3.5 **ignition**: In the test, ignition is considered to have occurred when:

– a pressure rise of at least 0,2 bar above any pressure introduced by the igniting spark is measured in a closed vessel (e.g. 20 l sphere); or

– a flame which propagates at least 6 cm away from the spark position is observed in an open tube (e.g. Hartmann tube).

3.6 **ignition delay time**: Time between dispersion of the dust and the occurrence of the spark discharge.

4 Test apparatus

4.1 *Spark generation circuit*

Annex A describes some suitable forms of circuit, all of which shall have the following characteristics. What follows deals only with the circuit:

– inductance of discharge circuit: 1 mH to 2 mH except when the data is to be used for the assessment of electrostatic hazards when the inductance of the discharge circuit shall not exceed 25 µH;

– ohmic resistance of discharge circuit: as low as possible and not more than 5 Ω;

– electrode material: stainless steel, brass, copper or tungsten;

– electrode diameter and shape: 2,0 mm ± 0,5 mm. Electrodes with rounded tips can be used to reduce corona effects that can occur with pointed electrodes, and which may give incorrect values of spark energy. If pointed electrodes are used, corona effects should be carefully considered;

- electrode gap: 6 mm (minimum);
- capacitors: low-inductance type, resistant to surge current;
- capacitance of electrode arrangement: as low as possible;
- insulation resistance between electrodes: sufficiently high to prevent leakage currents.

NOTE – Typically, a minimum resistance between the electrodes of 10^{12} Ω is required for a minimum ignition energy of 1 mJ, and 10^{10} Ω for a minimum ignition energy of 100 mJ.

4.2 *Test vessel*

The recommended vessels are the 20 l sphere apparatus and the Hartmann tube. These vessels are described in references [6] and [7]*. Other vessels can be used, provided that the calibration requirements in 6.2 are met.

5 Test sample

Tests shall be performed on samples in a state of preparation corresponding to that found in practice under plant conditions.

Minimum ignition energy decreases with decreasing particle size. Tests shall be carried out on samples having particle sizes that are consistent with, or finer than, the finest material that can be present in the intended use.

For comparative tests the samples shall be prepared by a constant method with the object of fixing particle size distribution and moisture content.

NOTE – Where the particle sizes of the material are not known, tests should be carried out on particle sizes less than 63 μm.

Minimum ignition energy decreases with decreasing particle size. It should be checked that the particle sizes of the sample are representative of the finest material that can be present in the plant. Tests should be carried out on material of particle size less than 63 μm.

6 Procedure

6.1 *Brief description*

The combustible dust to be tested is uniformly dispersed in air at atmospheric pressure and temperature in a suitable apparatus, and the dust/air mixture is subjected to a spark discharge from a charged capacitor.

The energy value of the discharge is calculated from the formula:

$$W = 0{,}5\ C \times U^2$$

where

W is the stored energy in joules (J);

C is the total discharge capacitance, in farads (F);

U is the voltage of the charged capacitor in volts (V).

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* Figures in square brackets refer to the bibliography, annex C.

NOTES

1 At spark energies above 100 mJ, the spark resistance can become so small that the circuit resistance is no longer negligible compared with the spark resistance, particularly when the circuit contains an inductance coil of the order of 1 mH. In such cases the net spark energy can be obtained from the equation:

$$W = \int I(t)\ U(t) \mathrm{d}t$$

where

$I(t)$ is the spark current, and

$U(t)$ the spark voltage; both of which are obtained by measurement.

2 Further information relative to the calculation of spark energies is contained in annex A.

It is necessary to take account of the following possible influences on the test:

– dust/air mixture aerodynamics (e.g. ignition delay time, dispersing pressure);

– dust concentration;

– voltage to which the capacitor is charged;

– capacitance of the capacitor;

– inductance of the discharge circuit;

– ohmic resistance of the discharge circuit;

– materials and dimensions of the electrodes and the gap between the electrodes.

To limit the expense of testing, every apparatus uses electrodes composed of a specific material with standardized dimensions and minimum electrode gap. The ohmic resistance of the discharge circuit shall be kept as low as possible (see clause 4).

Starting with a spark energy that will reliably cause ignition of the dust being tested, the dust concentration and dust dispersion parameters (e.g. ignition delay time and dispersion pressure) are adjusted to establish the most ignitable dust cloud. Using the optimal conditions for ignition, the spark energy is successively halved, by adjusting the capacitance of the capacitor and/or the voltage to which it is charged, until no ignition occurs in 20 successive tests.

NOTE – When tests are carried out using the 20 l sphere apparatus, the ignition delay time should be 120 ms.

The minimum ignition energy, W_{min}, lies between the highest energy, W_1, at which ignition fails to occur in 20 successive attempts to ignite the dust/air mixture, and the lowest energy, W_2, at which ignition occurs within 20 successive attempts.

$$W_1 < W_{min} < W_2$$

6.2 *Calibration*

Calibration tests should be carried out on three reference dusts which shall have been dried under atmospheric pressure at 50 °C for 24 h prior to the measurements.

The results shall be within the following ranges:

lycopodium: W_{min} = 5 to 15 mJ, mean particle diameter 31 µm;
anthraquinone: W_{min} = 2 to 6 mJ, mean particle diameter 18 µm;
polyacrylonitrile: W_{min} = 2 to 6 mJ, mean particle diameter 27 µm.

The dust dispersion parameters, including ignition delay time, for each sample shall be noted.

6.3 *Test report*

Where the test has been carried out in accordance with this standard, the test report shall provide the information listed in 6.3.1, 6.3.2 and 6.3.3. Although the dust concentration values associated with the limits of the range of minimum ignition energy should be recorded by the test laboratory, the values, expressed in terms of the amount of dust which is weighed, divided by the volume of the explosion vessel, are not usually included in the test report.

6.3.1 *Product characteristics*

– sample designation (name and chemical description if not implicit in the name);

– sample origin or source;

– sample pre-treatment;

– characteristics data for particle size distribution and moisture content if available and not already given by pre-treatment procedures.

6.3.2 *Characteristics of the test apparatus*

– triggering;

– explosion vessel;

– dust-dispersion system;

– total inductance of the discharge circuit;

– charging voltage, electrode material and length of gap of the optimized discharge circuit.

6.3.3 *Results*

– highest energy W_1 at which ignition does not occur;

– lowest energy W_2 at which ignition is obtained.

6.3.4 *Report form*

An example of a suitable form is given in figure A.1.

Annex A
(informative)

Examples of spark-generating systems

A.1 General

Clauses A.2, A.3, A.4 and A.5 contain descriptions of four designs of spark-generating circuit suitable for use in this test. With any of these examples it is possible to use different explosion vessels, provided that the dust dispersion is optimized and that suitable precautions are taken in order to prevent side-effects occurring in comparatively large vessels from electrostatic charging phenomena during the dispersion of the dust. These phenomena include additional charging/discharging of the capacitor.

If the storage capacitor is decoupled from the electrode during the charging process, the effect of the decrease in voltage that will occur due to the increase in capacitance when the connection to the electrode is made, should be taken into account in calculating the spark energy. In all calculations of energy the total capacitance of the discharge circuit should be used, and the voltage at the time of discharge.

A.2 Triggering by auxiliary spark using three-electrode system

Figure A.2 illustrates the general arrangement of the test apparatus.

The essential component is a three-electrode spark gap. The two electrodes forming the main spark gap (1) are 3,2 mm in diameter, their ends being reduced to a diameter of 2,0 mm over a length of 20 mm. The free end of the auxiliary electrode (2) is angled toward the main spark gap, the length of this angled portion being 20 mm. This electrode arrangement is installed in an open-top Hartmann tube and is also suitable for installation in other explosion vessels.

Following the introduction into the mixture-generating device of the desired quantity of dust, the tube is placed in position. The test capacitor C (20 pF to 10 000 pF), which stores the ignition energy, is charged by means of the high-voltage charging unit HVCU across the charging resistance *R* which limits the charging current to 1 mA. The attempts to ignite the dust/air mixture are initiated by means of the control facility CF. Initiation of each attempt involves, first of all, triggering the device which disperses the dust into suspension, followed, after a predetermined interval, by the auxiliary spark and, with it, the triggering of the main spark discharge by the test capacitor.

The energy of the auxiliary circuit is limited to not more than one-tenth of the energy of the main discharging circuit.