Potentially explosive atmospheres — Explosion prevention and protection — Determination of minimum ignition energy of dust/air mixtures

The European Standard EN 13821:2002 has the status of a British Standard

ICS 13.230

British Standards

National foreword

This British Standard is the official English language version of EN 13821:2002.

The UK participation in its preparation was entrusted to Technical Committee FSH/23, Fire precautions in industrial and chemical plant, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Health and Environment Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 29 November 2002

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 16, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 40872 8

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13821

November 2002

ICS 13.230

English version

Potentially explosive atmospheres - Explosion prevention and protection - Determination of minimum ignition energy of dust/air mixtures

Atmosphères explosibles - Prévention et protection contre l'explosion - Détermination de l'énergie minimale d'inflammation des mélanges poussière/air

Explosionsfähige Atmosphären - Explosionsschutz - Bestimmung der Mindestzündenergie von Staub/Luft-Gemischen

This European Standard was approved by CEN on 16 October 2002.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13821:2002 E

Contents

Foreword

This document EN 13821:2002 has been prepared by Technical Committee CEN /TC 305 "Potentially explosive atmospheres - Explosion prevention and protection", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2003, and conflicting national standards shall be withdrawn at the latest by May 2003.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this document.

Annex A is normative.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard : Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a method of test to determine the minimum ignition energy of a dust/air mixture by an electrically-generated spark.

The test method is not suitable for use with recognised explosives, gunpowder, dynamite, explosives which do not require oxygen for combustion; pyrophoric substances, or substances or mixtures of substances which can under some circumstances behave in a similar manner. Where any doubt exists about the existence of a hazard due to explosive properties, expert advice should be sought.

WARNING — It is essential that precautions are taken to safeguard the health of personnel conducting the tests against the risk of fire, explosion and/or toxic effects, of combustion products.

2 Normative references

There are no normative references.

3 Terms and definitions

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

3.1
dust
small solid particles that are able to remain suspended in air for some time

NOTE Normally maximum particle sizes will not exceed 500 µm. This definition includes what are defined in ISO 4225 as 'dust' and 'grit'

3.2
combustible dust
dust able to undergo an exothermic reaction with air when ignited

3.3
explosive dust/air mixture
mixture of dust with air in which, after ignition has occurred, combustion spreads to the entire unburned mixture

3.4
spark discharge
transient discrete electric discharge which takes place between two electrodes which are at different potentials. The discharge bridges the gap between the conductors in the form of a single ionisation channel

3.5
minimum ignition energy of an explosive dust/air mixture
lowest electrical energy stored in a capacitor which upon discharge is just sufficient to effect ignition of the most ignitable mixture of a given dust under specific test conditions

3.6
ignition
propagation of a sustainable flame away from the spark discharge position

3.7
ignition delay time
time between the onset of dispersion of the dust sample into a cloud and the occurrence of the spark discharge

3.8
test conditions (temperature, pressure)
air having a temperature in the range from 20 °C to 25 °C and a pressure in the range from 0.8 bar to 1.1 bar, absolute

4 Test apparatus

4.1 Spark generation circuit

Annex A describes some suitable forms of circuit for spark generation all of which shall have the following characteristics:

a) inductance of discharge circuit: from 1 mH to 2 mH except when the data is to be used for the assessment of electrostatic hazards. Then the total inductance of the discharge circuit shall not exceed 25 µH;

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

c) electrode material: tungsten, stainless steel, brass, or copper;

d) electrode shaft diameter: 2.0 ± 0.5 mm;

e) electrode shape: pointed;

f) electrode gap: ≥ 6 mm (minimum);

g) capacitance of electrode arrangement: as low as possible. If the parasitic capacitance of the electrode system is significant compared with the discharge capacitance, it shall be taken into account;

h) insulation resistance between electrodes: sufficiently high to prevent leakage currents.

NOTE For low spark energies together with pointed electrodes a significant fraction of the energy in the capacitance can drain away as corona discharges prior to the spark discharge.

4.2 Test vessel

The recommended test equipment is the Hartmann apparatus described in references 7,8 and 10 in bibliography. This apparatus is shown in A.7.

NOTE The minimum ignition energy is independent of the volume ($V \geq 1$ l). Therefore it can also be determined in the 20-l-sphere or in the 1 m^3-vessel.

Other vessels may be used provided that the conformity requirements according to 6.3 are met.

5 Test sample

The minimum ignition energy decreases with decreasing particle size. Therefore the particle size distribution shall be determined for the sample as tested and shall be indicated in the test report.

The minimum ignition energy decreases with decreasing moisture content. Therefore the moisture content shall be determined for the sample as tested and shall be indicated in the test report.

NOTE 1 Where the particle sizes of the material in the plant are not known, tests should be carried out on dust samples of particle sizes e.g. less than 63 µm.

NOTE 2 The size of the dust particles can be reduced by the dispersion process. In cases, where this effect can be important, its magnitude can be evaluated by measuring the particle size distribution after dispersion (without ignition).

NOTE 3 Grinding can alter the particle shape and surface condition, and sieving can alter the proportion of inert in the sample. A rough classification of the shape of the dust particles may also be necessary („spherical“, „flat“ or „fibrous“).

NOTE 4 Where the moisture content in the plant is not known, the sample should be carefully dried, e.g. at 50 °C under vacuum, or at 75 °C and atmospheric pressure until the sample weight has reached a constant value.

6 Test procedure

6.1 Test description

The dust to be tested is dispersed in air at test conditions (specified in 3.8) in the test-apparatus, and the dust cloud is subjected to a spark discharge from a capacitor.

The energy value of the discharge is calculated from the equation

$$E = 0{,}5\ C \cdot U^2 \tag{1}$$

where:

E is the stored energy in joules [J];

C is the total capacitance of the discharge circuit in farads [F] and

U is the voltage of the capacitor in volts [V].

NOTE 1 Further information relevant to the calculation of spark energies is contained in annex A.

NOTE 2 The following possible influences on the test should be considered:

- dust/air mixture dynamics/turbulence (a function of ignition delay time and dispersing pressure etc.);
- dust concentration;
- voltage of the capacitor;
- capacitance of the discharge circuit capacitor;
- inductance of the discharge circuit;

- ohmic resistance of the discharge circuit;
- materials and dimensions of the electrodes and the gap between the electrodes.

The minimum ignition energy is a function of the dust/air mixture dynamics/turbulence and the dust concentration. The minimum ignition energy shall be measured at the optimum dust concentration and the lowest turbulence level experimentally attainable. The turbulence level is reduced by extending the ignition delay time until as long a delay time as is feasible for the apparatus is determined.

The optimum dust concentration and the lowest turbulence level cannot be obtained in one step. Therefore an iterative procedure is required of which the main steps are as follows:

Step 1

Start with a value of ignition energy that will reliably cause ignition of a given concentration in air of the dust being tested. Reduce the spark energy in steps (e.g. by 50%) at the given dust concentration until the dust cloud does no longer ignite in any of 10 tests at a given energy.

Step 2

Continue the procedure varying the dust concentration at the lowest energy found in Step 1. If for any dust concentration an ignition occurs, then repeat Step 1 at that concentration.

Step 3

Repeat the procedure by this combination of spark energy and dust concentration varying the delay time (turbulence) until the maximum energy (E_1) is found where no ignition occurs.

The minimum ignition energy MIE lies between the highest energy, E_1, at which ignition fails to occur in 10 successive attempts to ignite the dust/air mixture, and the lowest energy, E_2, at which ignition occurs within up to 10 successive attempts.

$$E_1 < \text{MIE} < E_2 \qquad (2)$$

6.2 Calibration

At regular intervals (at least every 12 months, or following any significant maintenance or repair) the apparatus shall be calibrated by:

a) checks of components

1) energy of the discharge: capacitance of capacitors and voltage applied/generated;

2) inductance of the circuit;

3) ohmic resistance of the circuit;

4) capacitance of the circuit;

5) the dust dispersion systems: delay time and dispersion pressure.

b) calibration of total system

Calibration shall be carried out using one of the following tests:

- internal calibration with at least one reference dust the MIE of which is known. The results of the E_S-value (see section 6.3) shall differ by less than a factor of 3 to prove the positive outcome of the calibration.
- comparative measurement of minimum ignition energy with at least one other laboratory with at least one reference dust. The results of the E_S-value (see section 6.3) shall differ by less than a factor of 3.

For the purposes of internal calibration dusts shall be chosen on the basis of evidence that their minimum ignition energy does not change significantly over the period between calibrations.

6.3 Conformity

6.3.1 Conformity tests

The minimum ignition energy may be determined using alternative equipment and/or test procedures providing it can be demonstrated that the conformity has been proven. The criteria for demonstrating conformity shall be as follows:

Conformity tests shall be carried out on at least five different dusts from each of the following energy ranges (minimum 15 dusts) in co-operation with one or more laboratories having a calibrated MIE-Apparatus.

Energy ranges:	1mJ	-	10 mJ
	10 mJ	-	100 mJ
	100 mJ	-	1000 mJ

At least two metal powders, two natural organic powders, two synthetic organic powders and two coal dusts shall be tested.

In cases where the test apparatus is not used to determine the minimum ignition energy for all energy ranges, it is possible to calibrate the test equipment for 1 or 2 energy ranges.

6.3.2 Criteria for conformity

The minimum ignition energy MIE lies, by definition, between two energy values:

E_1 < MIE < E_2

For the purpose of comparison between different apparatus, only one single value (E_S) instead of the energy range (E_1, E_2) shall be used. This single value E_S can be estimated by use of the probability of ignition as follows:

Provided that for the energy E_2 a minimum of 5 evenly distributed dust concentrations are tested, the position of E_S in the E_1 - E_2 range can be estimated. In the exponent of the following equation, at the ignition energy E_2, the number of dust concentrations with ignition (I[E_2]), is divided by the total number of dust concentrations ((NI+I)[E_2]) tested.

$$E_S = 10^{\log E_2 - \frac{I[E_2]\cdot(\log E_2 - \log E_1)}{(NI+I)\cdot[E_2]+1}} \tag{3}$$

Example:

energy	dust concentration in mg					ignition probability
	300	600	900	1200	1500	
E_2 = 30 mJ	NI	I	I	I	NI	→ 3 of 5
E_1 = 10 mJ		NI	NI	NI		

where:

I means „ignition“ and

NI means 10 times „no ignition“.

Following the above equation, this example results in a value $E_S \cong 17$ mJ.

Conformity between two sets of equipment is given, when E_S-values for all dusts tested differ less than a factor of 3.

6.4 Test report

The test report shall include at least the following information:

a) name and address of testing house where the test was carried out;

b) unique identification of report (such as serial number) and of each page, and total number of pages of the report;

c) description and identification of the sample tested (Product characteristics):

- sample designation (name or chemical composition etc.),
- if applicable, sample pre-treatment (sieving, drying, grinding),
- moisture content as a percentage by mass (incl. method),
- particle size distribution, included median value in µm (incl. method),
- rough classification of shape („spherical“, „flat“ or „fibrous“).

d) date of receipt of test item and date(s) of performance of test;

e) characteristics of the test apparatus:

- method of spark generation (see annex A);
- explosion apparatus (type).

f) any deviations of the test method and conditions described in this standard and any other information relevant to a specific test;

g) results

$$E_1 < \mathrm{MIE} < E_2 \tag{4}$$

- E_1, highest energy, at which ignition does not occur;
- E_2, lowest energy, at which ignition is obtained.

h) signature and title or an equivalent marking of the person accepting technical responsibility for the test report and date of issue;

i) a statement to the effect that the test results relate only to the samples tested.

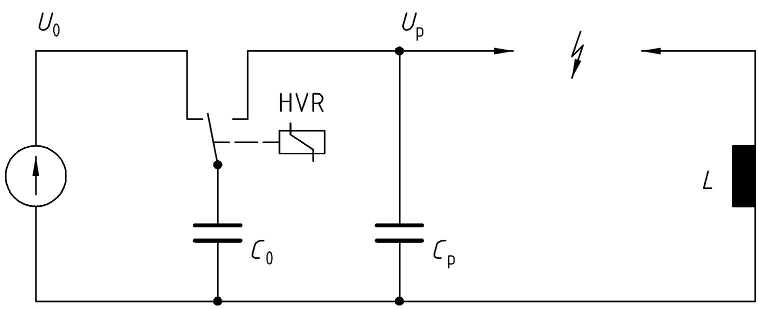
Annex A
(normative)

Descriptions of spark generating systems

A.1 General

A.2 to A.6 contain descriptions of five designs of spark generating circuits. With any of these examples it is possible to use different explosion vessels, provided that the dust dispersion is optimised 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.

A.2 Triggering by high-voltage relay, using a two-electrode system



Key

U_0 charging voltage

U_p discharge voltage

C_0 storage capacitance

C_p parasitic capacitance

L inductance (additional)

HVR high-voltage relay

Figure A.1

For very low energies the unavoidable parasitic capacity of the electrode arrangement is in the same order of magnitude as the storage capacitor. Therefore the parasitic capacity shall be kept constant and the voltage of the spark shall be calculated as follows:

$$U_p = U_0 \cdot C_0 / (C_0 + C_p) \qquad \text{(A.1)}$$

This results in a spark energy E according to the following equation:

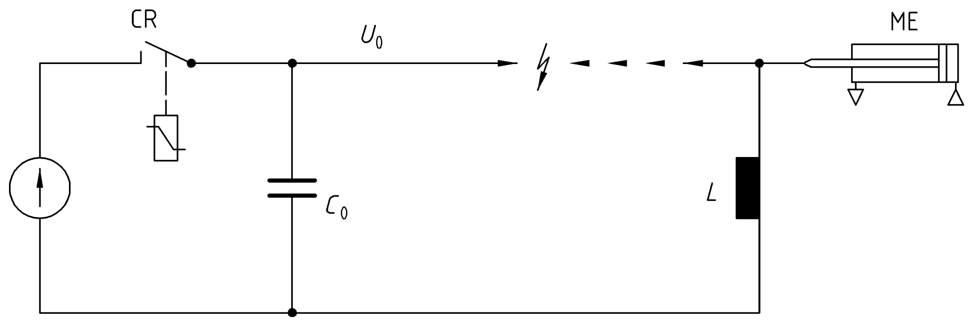
$$E = 0,5 \cdot (C_0 + C_p) \cdot U_p^2 \qquad \text{(A.2)}$$

The storage capacitor C_0 acquired the charge $Q_0 = U_0 \cdot C_0$. After switching of the relay „HVR“, the charge is retained, but the voltage U_0 is lowered to U_p.

Limitations:

This triggering circuit is suitable only for very low energies of the spark. For energies above 10 mJ the high voltage relay is not able to handle the high discharge current.

A.3 Triggering by electrode movement, using a two-electrode system



Key

U_o charging voltage

C_o storage capacitance

L inductance (additional)

ME moving electrode

CR charging relay

Figure A.2

At the start, the moving electrode is in the home position. Then the electrode gap is so wide that the breakdown voltage is never reached. After opening of the charging relay „Charge“, the electrode (ME) is moved rapidly by the pneumatic system to the set minimum electrode gap of 6 mm. Sparkover occurs before the end position is reached.

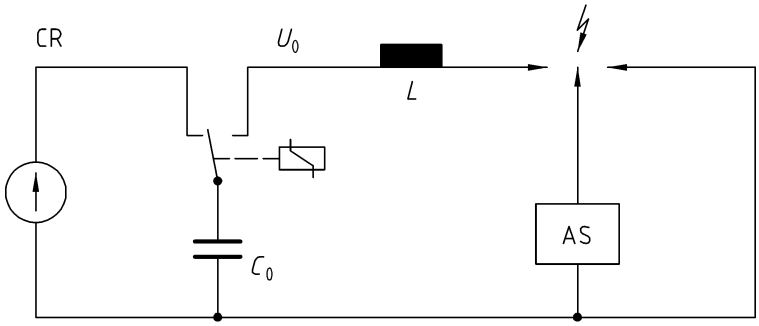
The spark energy „E“ is calculated according to the following equation:

$$E = 0{,}5 \cdot C_0 \cdot U_0^2 \quad \text{(A.3)}$$

Limitations:

During the movement of the electrodes, the energy stored in the capacitor C_o decreases due to the corona current flowing from the electrode tips. This type of spark triggering is thus admissible only with energy values above 10 mJ, where this corona loss is negligibly small.

A.4 Triggering by auxiliary spark, using 3-electrode system



Key

U_0 charging voltage

C_0 storage capacitance

L inductance (additional)

CR charging relay

AS trigger circuit for auxiliary spark

Figure A.3

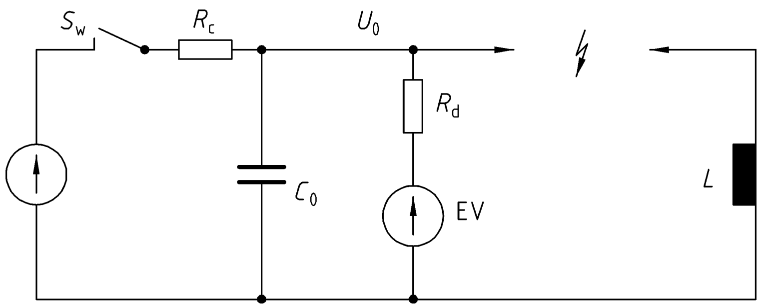
The charging voltage U_0 is selected so that a sparkover cannot occur over the main spark gap of 6 mm - the capacitor C_0 will not discharge without ionisation of the air. Ionisation of the air only is achieved by activating the auxiliary spark. Usually the auxiliary spark is generated by interruption of the current flowing in the primary winding of an ignition coil.

Limitations:

The energy of the auxiliary spark is limited to not more than 1/10 of the energy of the main discharging circuit. Therefore for energies of the main spark below 5 mJ the energy of the auxiliary spark becomes too small for ionisation of the air.

Before the main spark jumps, the energy stored in the capacitor C_0 decreases owing to the corona current flowing from the electrode tips. This has to be considered at low spark energies.

A.5 Triggering by voltage increase, using two-electrode system



Key

U_o spark voltage

C_0 storage capacitance

L inductance (additional)

S_w high voltage switch

R_c current limiting resistor

R_d decoupling resistor

EV electrostatic voltmeter

Figure A.4

When the switch S_w is closed, the high voltage supply slowly charges through the limiting resistor R_c the capacitor C_0 and raises the potential to a value U_S at which a spark occurs. The cycle is then repeated, giving a series of sparks each of the same energy. The current limiting resistor R_c has a value between 10^8 and 10^9 ohm. The potential across the capacitor C_0 is measured by an electrostatic voltmeter with a decoupling resistor in series having a value between 10^8 and 10^9 ohm. Sparks of any energy level from 1 mJ upwards can be readily produced using this circuit by varying the value of the capacitor and, if necessary, the discharge voltage.

Test procedure:

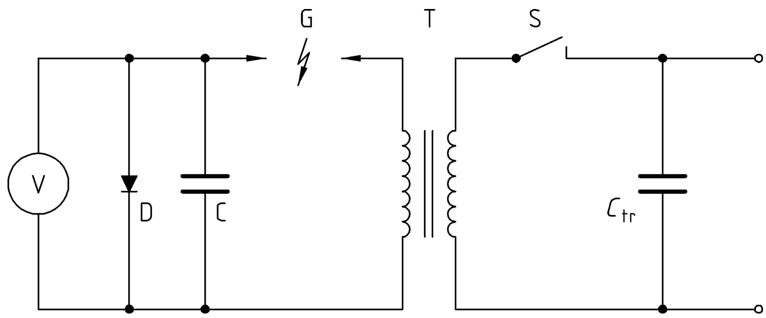
The settings for sparks of the required energy are determined before any dust is placed in the test vessel. A capacitor of the appropriate value is chosen and a voltage in the range 10 kV to 30 kV selected. The voltage and electrode separation are then adjusted by trial until sparks of the required energy, given by $E = 0.5 \cdot C_0 \cdot U_S^2$ occur at the electrodes. In this expression, U_S is the voltage at which the spark occurs and C_0 is the total capacitance at the high voltage electrode. In order to make an ignition test, the required quantity of the prepared dust is placed in the dispersion cup. The high voltage supply is then switched into the circuit and as sparks start to pass between the electrodes the powder is dispersed by an air jet. It is noted whether ignition occurs.

The repetitive sparkover and the forming of the dust cloud are not synchronised, therefore the turbulence and dust concentration are randomly distributed. The number of no-ignition trials shall be raised to 50 tests for each energy level.

Limitations:

An adjustment of the electrode gap below 6 mm shall be avoided. Therefore an energy below 10 mJ requires a very small capacitor C_0 and an impractical high (10^9 ohm) charging resistor R_c.

A.6 Triggering by transformer, using two-electrode system



Key

C main capacitance

C_{tr} capacitor in trigger circuit

D diode

S switch

T transformer

G spark gap

Figure A.5

C is the discharge capacitor, having an initial voltage of *U*. By having a range of capacitors from 40 pF and downwards in steps of a factor of ten, and variable voltage from 1000 V downwards [400 to 500 V is a practical minimum level], a wide selection of $0{,}5 \cdot C \cdot U^2$ values is available. Initiation of spark discharge at the desired moment, which is essential if synchronisation of spark discharge with the formation of a transient dust cloud is required, is accomplished by means of the trigger circuit in which the capacitor C_{tr}, a switch S, and the primary coil of the trigger transformer T constitute the essential elements. By closing the switch, a high voltage pulse of approximately 15 kV peak value is induced in the secondary coil of the transformer, causing breakdown of the spark gap G, and thereby discharge of the main capacitor *C*.

The net spark energies generated for various combinations of *C* and *U* are determined in the conventional way by measuring current and voltage at the spark gap as functions of time and integrating the power-versus-time curve. The function of the diode D is to produce unidirectional discharges only. The self-inductance of the secondary coil of the trigger transformer shall be 1 to 2 mH.

Limitations:

This circuit shall not be used for tests without inductance, because the inductance constitutes a central element of the trigger arrangement.

Experience has shown that it is very difficult to reduce the energy input to the spark gap by the trigger spark to below 2 to 5 mJ. For this reason this trigger principle shall only be used when the spark energies are above 5 mJ.

A.7 Example of a test apparatus

A modified Hartmann tube made of glass with a volume of 1,2 l is used as the explosion vessel. The dust dispersion system at the base of the tube is of the "mushroom-shaped" type around which the sample is loosely scattered. A blast of compressed air at 7 bar overpressure is used to disperse the dust in the glass cylinder where it is ignited by a spark between two electrodes.

Dimensions in millimetres

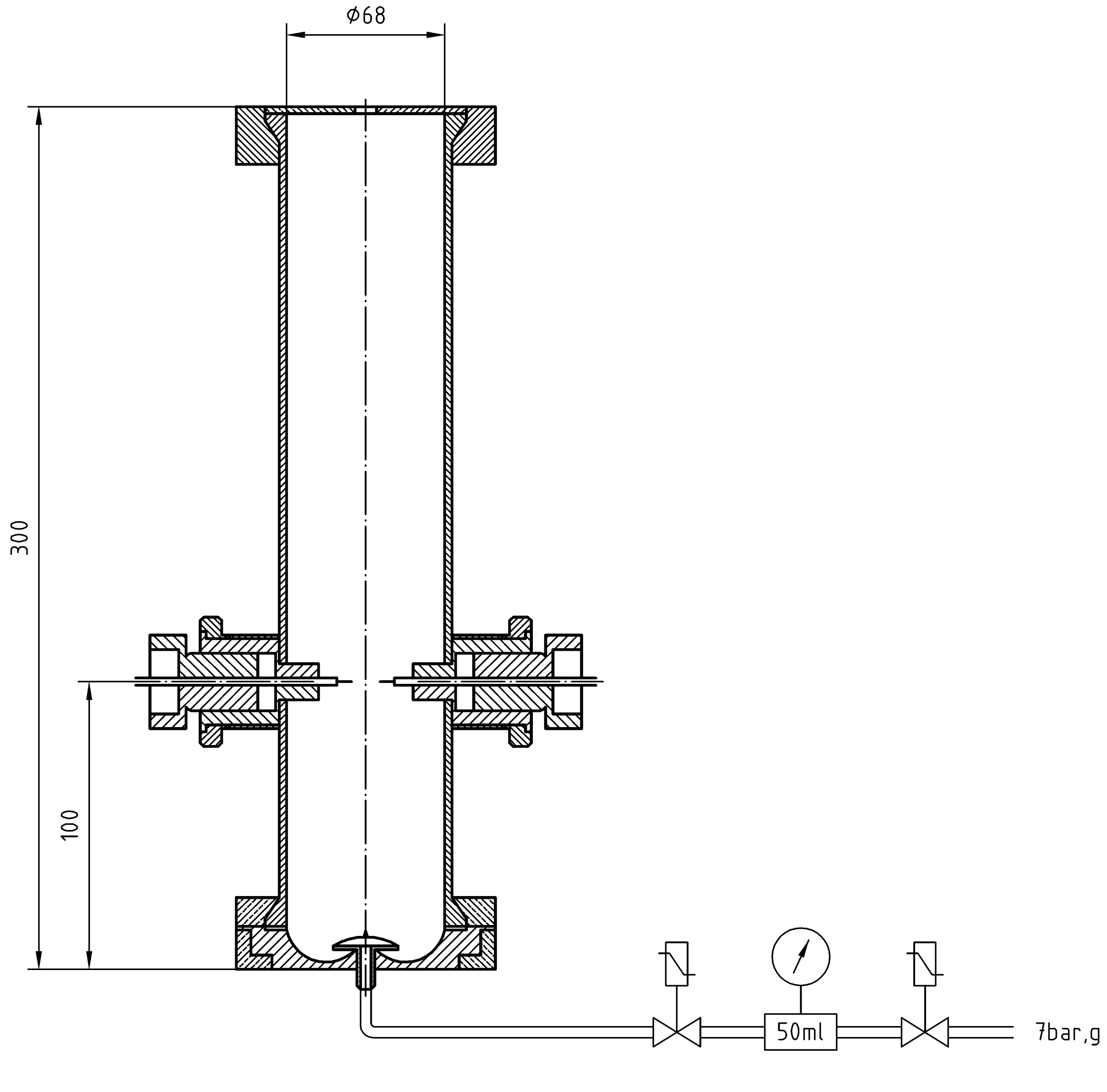


Figure A.6

Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives.

This European standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of the following EU Directives.

Council Directive of 14 June 1989 on the approximation of the laws of the Member States relating to machinery (89/392/EEC);

Directive 94/9/EC of the European Parliament and the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

The clauses of this standard are likely to support requirements of the two above-mentioned Directives. The following two tables establish the relationship between the relevant requirements of the descriptive Directives and the clauses of this European Standard deal with them:

Table A.1 — Relationship between Directive 89/392/EEC and clauses of this standard

Essential requirement of Directive 89/392/EEC	dealt with in this European Standard in clause
Annex I, 1.5.7 Explosion 4 to 7	4 to 6 and annex A

Table A.2 — Relationship between Directive 94/9/EC and clauses of this standard

Essential requirement of Directive 94/9/EC	dealt with in this European Standard in clause
Annex II, with the exception of the following clauses:	4 to 6 and annex A

Compliance with this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

Bibliography

The following published documents are useful sources of reference; some being quoted in the text.

[1] Ritter K. Mechanisch erzeugte Funken als Zündquellen. VDI Berichte 494 (1984), VDI-Verlag, Düsseldorf

[2] Bartknecht W. Die Zündwirksamkeit von mechanisch erzeugten Funken und heissen Oberflächen in Staub/Luft- und Brenngas/Luft-Gemischen. VDI-Fortschrittsberichte Nr.180 (1989)

[3] Franke H. VDI-Berichte 304, VDI Verlag, Düsseldorf (69-72)

[4] Pellmont G. Explosions- und Zündverhalten von hybriden Gemischen aus brennbaren Stäuben und Brenngasen. Dissertation ETH Zürich, No. 6498 (1979)

[5] Bartknecht W. Explosionsschutz, Grundlagen und Anwendungen, Springer - Verlag, Berlin (1993)

[6] Siwek R. Zuverlässige Bestimmung explosionstechnischer Kenngrössen in der 20-Liter-Laboratapparatur. Preceedings of the Colloquium "Sicherheit Handhabung brennbarer Stäube" Nürnberg 1988, VDI-Berichte 701, Verlag des VDI, Düsseldorf

[7] Field P. Dust Explosions Handbook of Powder Technology, volume 4 Elsevier Amsterdam, 1982

[8] Eckhoff R.K. Dust Explosions in the Process Industries, Section 5.3, Butterworth-Heinemann, Oxford, sec. Ed. 1997

[9] Alvestad B. An electric spark generator for determination of minimum ignition energies for dust clouds. Chr. Michelsen Institute Research Report No. 803301-3, November 1980

[10] Bartknecht W., R. Siwek Die Bedeutung von Mindestzündenergie und Zündtemperatur für die Beurteilung der Zündwirksamkeit von Zündquellen in Staub/Luft-Gemischen, Staub-Reinhaltung der Luft 54 (1994) S.325 - 330 bzw. S.415 - 421, Springer-Verlag, Berlin (1994)

[11] Luettgens G. /Glor M. Understanding and Controlling Static Electricity Expert Verlag, Ehningen bei Böblingen, 1989

[12] Beck H., N. Glienke u. C. Möhlmann: Combustion and explosion characteristics of dusts. BIA-Report 13/97

[13] Glarner, Th.: Temperatureinfluss auf das Explosions- und Zündverhalten brennbarer Stäube, Diss. ETH Zürich, Nr. 7350, 1983

[14] Van Laar, G.F.M.: "Influence of moisture content on the minimum ignition energy (MIE) of dust/air mixtures". Report on the working group Minimum Ignition Energy, Prins Maurits Laboratorium TNO, November 1983

[15] Glarner, Th.: Mindestzündenergie - Einfluss der Temperatur - VDI-Berichte , 494, S. 109-118, VDI-Verlag Düsseldorf, 1984

[16] Cesana, Ch, Siwek, R.: Ignition Behavior of Dusts. Proceedings of the Loss Prevention Symposium, Atlanta, USA , April 17-21., 1994, American Institute of Chemical Engineers, 345 E. 47. Street, New York, 1994

[17] Siwek, R., Cesana, Ch.: Ignition Behavior of Dust: Meaning and Interpretation, Process Safety Progress (Vol. 14, No. 2), April 1995

blank

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL