SLOVENSKI STANDARD
SIST EN 13673-2:2006

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Ugotavljanje najvišjega tlaka eksplozije in največje hitrosti naraščanja tlaka plinov in hlapov - 2. del: Ugotavljanje največje hitrosti naraščanja tlaka eksplozije

Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours - Part 2: Determination of the maximum rate of explosion pressure rise

Verfahren zur Bestimmung des maximalen Explosionsdruckes und des maximalen zeitlichen Druckanstieges für Gase und Dämpfe - Teil 2: Bestimmungsverfahren für den maximalen zeitlichen Druckanstieg

Détermination de la pression maximale d'explosion et de la vitesse maximale de montée en pression des gaz et des vapeurs - Partie 2: Détermination de la vitesse maximale de montée en pression

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This European Standard was approved by CEN on 1 August 2005.

CEN 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 CEN 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 CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Foreword

This European Standard (EN 13673-2:2005) 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of an identical text or by endorsement, at the latest by March 2006, and conflicting national standards shall be withdrawn at the latest by March 2006.

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 EU Directives.

For relationship with EU Directives, see informative Annex ZA, which is an integral part of this document.

EN 13673 *Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours* consists of:

— *Part 1:* Determination of the maximum explosion pressure

— *Part 2:* Determination of the maximum rate of explosion pressure rise

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

Introduction

This European Standard describes a test method for the determination of the rate of explosion pressure rise and the maximum rate of explosion pressure rise of a quiescent flammable gas/air/inert mixture at ambient temperature and pressure.

Rate of explosion pressure rise and maximum rate of explosion pressure rise are used for designing explosion protection measures, such as explosion pressure resistant or explosion pressure shock resistant apparatus, explosion venting and explosion suppression. These characteristics are particularly influenced by:

— the size and shape of the vessel;

— the type and energy of the ignition source;

— the temperature and pressure;

— the turbulence.

It is therefore necessary to standardise the conditions at which the rate of explosion pressure rise and the maximum rate of explosion pressure rise are determined.

1 Scope

The standard test method is designed to produce measurements of the rate of explosion pressure rise and the maximum rate of explosion pressure rise of a flammable gas/air/inert mixture in a closed volume at ambient temperature and pressure. In this European Standard, the term "gas" includes vapours but not mists. Detonation and decomposition phenomena are not considered in this European Standard.

The rates of pressure rise measured by the procedures specified in this European Standard are not applicable to flameproof enclosures, that is enclosures intended to withstand an internal explosion and not to transmit it to an external explosive atmosphere, or any other closed volume where the internal geometry can result in pressure piling. Even in an enclosure of relatively simple geometry the disposition of the internal components can lead to rates of pressure rise significantly higher than those measured using this European Standard. Flameproof enclosures shall be constructed and tested in accordance with the requirements contained in EN 60079-1 for electrical equipment and EN 13463-3 for non-electrical equipment.

2 Normative references

Not applicable.

3 Terms and definitions

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

3.1
rate of explosion pressure rise
$(dp/dt)_{ex}$
highest value of the slope (first derivative) of the pressure-time curve (smoothed if necessary), measured in a closed vessel during the explosion of a specific mixture of flammable gases with air or air and inert gases determined under specified test conditions

3.2
maximum rate of explosion pressure rise
$(dp/dt)_{max}$
maximum value of the rate of explosion pressure rise, when varying the content of flammable gas in the mixture

NOTE For the purpose of this document, all pressures are expressed in bar absolute and rate of explosion pressure rises are expressed in bar/s.

4 Test method

4.1 Principle

An explosive test mixture is ignited by a defined ignition source which is positioned in the centre of the test vessel. By means of a pressure measuring system, the pressure-time curve developed following ignition of the test mixture is recorded and the highest rate of explosion pressure rise $(dp/dt)_{ex}$ is calculated. The maximum rate of explosion pressure rise $(dp/dt)_{max}$ is determined from measurements of the highest rate of explosion pressure rise $(dp/dt)_{max}$ by varying stepwise the content of flammable gas in the mixture, until the maximum $(dp/dt)_{ex}$ is found.

4.2 Apparatus

4.2.1 General

The test apparatus consists of:

— a test vessel;

— equipment for preparing the test mixture;

— an ignition system;

— a pressure measuring system;

— a temperature measuring device;

— safety equipment.

4.2.2 Test vessel

The test vessel shall be spherical or cylindrical. The internal volume of the test vessel shall be equal to or greater than 0,005 m^3. If a cylindrical vessel is used, the length to diameter ratio shall be equal to 1.

The test vessel and any equipment (valves, igniter, transducer etc.) fitted on the vessel shall be designed to withstand a maximum pressure of at least 20 bar.

NOTE Guidance on the design of the test vessel can be found in prEN 14460 [1].

The vessel shall be made of stainless steel or any material free of any catalytic effects and resistant to corrosion from the initial gas mixture and the products of combustion.

The test vessel shall be fitted with sufficient ports to allow filling, evacuating and purging of the vessel.

4.2.3 Equipment for preparing the test mixture

The test mixture can be prepared by the method of partial pressures or by the method of mixing flows, either inside or outside the test vessel.

If the test mixture is prepared by partial pressures, the vessel used for the preparation of the mixture shall be fitted with:

— a vacuum pump and a vacuum gauge;

— pressure gauges or manometers;

— a means of achieving a uniform test mixture (e.g. a stirrer).

If the test mixture is prepared by mixing flows, the necessary components are:

— flow meters (mass or volume flow meters);

— a means of achieving a uniform test mixture (e.g. mixing chamber);

— an evaporator if liquid samples are used (see Annex D for an example).

The equipment for preparing the test mixture has to be designed in such a way that the flammable gas content in the test mixture is measured with at least an uncertainty of measurement of ± 10 % relative for a flammable gas content up to 2 % mol or ± 0,2 % absolute for a flammable gas content above 2 % mol.

4.2.4 Ignition system

4.2.4.1 General

The igniter shall be positioned in the centre of the test vessel. Recommended ignition systems are the induction spark and the fusing wire. In the test report it has to be stated which ignition source was used.

For some special mixtures it may be necessary to use a different ignition system in order to achieve ignition of the mixture. If an alternative ignition source is used it shall be fully described in the test report. It is also recommended that specialist advice is sought on the interpretation of the results.

4.2.4.2 Induction spark

A series of induction sparks between two electrodes is used as the ignition source.

Stainless steel is a suitable material for the electrodes. The electrodes shall be positioned at the centre of the vessel. They shall be pointed rods with a maximum diameter of 4 mm. The angle of the tips shall be 60°. The distance between the tips shall be (5 ± 0,1) mm. The electrodes shall be mounted in the vessel so they are gas tight at the highest pressures generated during the test. The mounting shall be resistant to heat and the test mixture, and provide adequate electrical resistance from the test vessel body.

A high voltage transformer, with a root mean square of 13 kV to 16 kV and a short circuit current of 20 mA to 30 mA, shall be used for producing the ignition spark. The primary winding of the high voltage transformer shall be connected to the mains via a timer set to the required discharge time.

The spark discharge time shall be adjusted to 0,2 s. If a spark discharge time of 0,2 s does not result in ignition of the test mixture, the test may be repeated with a spark discharge time of up to 0,5 s.

The power of the spark depends on the gas mixture and its pressure. In air at atmospheric conditions according to calorimetric and electric measurements such a source gives a spark with a power of approximately 10 W.

4.2.4.3 Fusing wire

This ignition device generates an electric arc by passing an electrical current along a length of straight fusing wire connected between two metal rods.

The electrical power for melting the wire and generating the arc is supplied from an isolating transformer. The ignition energy delivered by the arc depends on the duration of the arc and the power rating of the isolating transformer. The energy delivered shall be in the range 10 J to 20 J, as over this range of energies there is no significant effect on the rate of explosion pressure rise. This is achieved by limiting the power rating of the isolating transformer to between 0,7 kVA and 3,5 kVA and by the use of a phase control technique. The latter is a chopping technique that allows only part of the AC waveform from the transformer secondary windings to energise the wire.

Brass or stainless steel are suitable materials for the rods. The rods shall be parallel to each other with a separation distance of (5 ± 1) mm. For the fusing wire a straight length of NiCr wire (diameter 0,05 mm to 0,2 mm) shall be soldered to the tips of the metal rods. The rods shall be positioned in the test vessel so the fusing wire is at the centre of the vessel. The electrodes shall be mounted in the vessel so they are gas tight at the highest pressures generated during the test. The mounting shall be resistant to heat and the test mixture, and provide adequate electrical resistance from the test vessel body.

To reduce the time required for replacing the fusing wire after a test, the rods may be mounted in a plug that can be screwed into the test vessel wall.

The cross-section of the wires connecting the transformer to the rods shall be between 2,5 mm^2 and 7 mm^2. The length of the wires shall be less than 5 m. The diameter of the rods shall be between 1,5 mm and 5 mm.

If for practical reasons the diameter of the rods has to be less than 3 mm additional mechanical support may be necessary.

4.2.5 Pressure measuring system

The pressure measuring system consists of:

— a pressure transducer;

— an amplifier;

— a data recording system.

To insure reliability, two pressure measuring systems may be used.

The pressure measuring system shall have an accuracy such that the initial pressure and explosion pressure are measured to ± 0,05 bar or better.

The pressure measuring system shall have a time resolution of at least 1 ms.

Pressure transducer:

The pressure transducer shall be fitted in the test vessel, with the head flush with the internal wall. It shall have a resonance frequency greater than 10 kHz. It shall be able to measure pressures up to 20 bar. Pressure transducers of lower range may be used if lower explosion pressures are expected.

Data recording system:

The data recording system shall have a resolution of 12 bit or 8 bit and its time resolution shall be equal to or shorter than $\frac{1}{500}t_{ex}$, the time from ignition to the maximum explosion pressure (see Figure B.1 and B.2).

4.2.6 Temperature measuring system

Any suitable thermocouple with appropriate recording equipment may be used.

4.2.7 Safety aspects

Precautions shall be taken to safeguard the health of personnel conducting the tests against the different hazards that can occur during the test:

— to prevent a leak of the mixture or waste gases outside the vessel, the gas tightness of the vessel shall be checked;

— to prevent rupture of the test vessel, it shall be designed to withstand a maximum pressure of at least 20 bar (see 4.2.2), as this can be assumed to be higher than the maximum explosion pressure likely to be generated during the test;

— if the test mixture is prepared in a separate vessel, this vessel and the connecting line shall be designed to withstand the maximum explosion pressure;

— to prevent injuries to the operator from flying fragments, all parts of the apparatus that may contain an explosive mixture shall be adequately shielded;

— adequate ventilation shall be provided to prevent the build up of an explosive atmosphere in the laboratory as a result of purging of the apparatus, exhaust from the vacuum pump or leaks from the apparatus;

— all electrical connections shall be adequately shielded to prevent electrocution or shock to personnel,

— measures shall be taken prior to preparing the mixture to ensure that the substances can be mixed without risk;

— measures shall be taken to prevent hazards arising from the handling of toxic flammables gases or combustion products;

— the handling of flammable liquids shall be carried out in such a manner that the risk of a fire is minimised;

— the handling of gas cylinders shall be carried out in such a manner that the risk of an explosion is minimised.

4.3 Preparation and preservation of test samples

The components of the test mixture shall fulfil the following requirements:

— Air: the air shall be free of water and oil. If synthetic air is used, it has to be stated in the report;

— Inert: the purity of the inert, or the mixture of inerts, shall be 99,8 % mol or better. If a mixture of inerts is used, the composition of the mixture shall be stated in the test report.

— Flammable gas: the flammable gas may be derived from:

  — a single substance or a mixture of substances;

  — a process sample (of known or unknown composition).

When a single substance or a mixture of substances is used, the purity of each substance shall be 99,8 % mol or better. In the case of a mixture of substances or a process sample of known composition, the precision of the composition shall be stated in the test report. In the case of a process sample of unknown composition, the sample shall be defined as well as possible (e.g. process conditions, lower explosion limit).

If the flammable gas is derived from a liquid containing more than one component, the gas phase composition can differ from the composition of the liquid phase and when large quantities of the gas are drawn off, the composition of both the liquid and gas phases can change with time. For these reasons, the test sample shall be taken from the liquid phase.

4.4 Procedure

4.4.1 Preparation of the test mixture

4.4.1.1 General

If liquefied gases or liquids are used, it is necessary to ensure that there is no condensation.

NOTE Condensation can be prevented by checking the vapour pressure of the substances and by local heating to prevent cooling at certain parts of the apparatus (e.g. valves).

The test mixture can be prepared by the method of partial pressures or by the method of mixing flows, either inside or outside the test vessel.

4.4.1.2 Preparation of the test mixture by partial pressures

If the preparation of the test mixture includes evacuating the vessel, the amount of air remaining has to be taken into account when calculating the pressures of combustible and air required. In preparing the test mixture, precautions may be necessary to prevent condensation.

The mixture components are sequentially introduced into the vessel to give the required partial pressure. The partial pressure measuring system shall have an accuracy of ± 0,005 bar or better. It is necessary to ensure that the mixture in the vessel is thoroughly mixed during the introduction of each component. If the volume of the feed lines is not negligible compared to the volume of the vessel, they also need to be evacuated or purged.

NOTE For practical reasons, air is often introduced as the last component, especially if atmospheric air is used.