SLOVENSKI STANDARD
SIST EN 1839:2003

01-december-2003

Ugotavljanje mej eksplozivnosti plinov in hlapov

Determination of explosion limits of gases and vapours

Bestimmung der Explosionsgrenzen von Gasen und Dämpfen

Determination des limites d'explosivité des gaz et des vapeurs

Ta slovenski standard je istoveten z: EN 1839:2003

ICS:

13.230	Varstvo pred eksplozijo	Explosion protection

SIST EN 1839:2003 **en,fr,de**

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1839

September 2003

ICS 13.230

English version

Determination of explosion limits of gases and vapours

Determination des limites d'explosivité des gaz et des vapeurs

Bestimmung der Explosionsgrenzen von Gasen und Dämpfen

This European Standard was approved by CEN on 7 August 2003.

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

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

Ref. No. EN 1839:2003 E

Contents

Foreword

This document (EN 1839:2003) 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of an identical text or by endorsement, at the latest by March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

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, B, C or D, which is an integral part of this document.

In this European Standard the annexes A, B, D and F are informative and the annexes C to E are normative.

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, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

To avoid the hazard of explosion, an appropriate measure is to prevent explosive mixtures of gases and/or vapours being formed. To do so, the explosion limits (also known as ”flammability limits”) of the flammable substance have to be known. These limits depend mainly on:

- the properties of the flammable substance,
- temperature and pressure,
- size and shape of the test vessel,
- ignition source (type, energy),
- the criterion for self-propagating combustion.

To obtain reliable and comparable results it is therefore necessary to standardize conditions (apparatus and procedure) under which the explosion limits are to be determined. It is however not possible to propose one method that is suitable for all substances. The use of an apparatus that can also be used for the determination of other explosion characteristics would also be a benefit. To these practical reasons the standard offers two methods, tube method (method T) and bomb method (method B). In general the tube method gives a wider explosion range. Differences in the explosion limits determined by the two methods can differ by up to 10 % relative.

1 Scope

This European Standard specifies two test methods (method T and method B) to determine the explosion limits of gases, vapours and their mixtures mixed with air. An air/inert gas mixture (volume fraction of the oxygen < 21 %) can be used as oxidizer instead of air. In this standard the term “air” includes such air/inert mixtures.

This European Standard applies to gases, vapours and their mixtures at atmospheric pressure and at temperatures from ambient temperature to 200 °C.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 1127-1:1997, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology.*

3 Terms and definitions

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

3.1
explosion range
range of the concentration of a flammable substance in air, within which an explosion can occur, respectively range of the concentration of a flammable substance in mixture with air/inert gas, within which an explosion can occur, determined under specified test conditions

NOTE Adapted from EN 1127-1.

3.2
explosion limits
limits of the explosion range

[EN 1127-1:1997, 3.7]

3.3
lower explosion limit
LEL
lower limit of the explosion range

3.4
upper explosion limit
UEL
upper limit of the explosion range

[EN 1127-1:1997]

NOTE 1 The values of the explosion limits vary with type and amount of inert gas added.

NOTE 2 In English literature the term ”flammability limits” is also used for describing the limits determined according to this standard. The term ”explosion limits” is chosen here to designate the same safety characteristics. This is done, because new regulations now use this term.

3.5
explosion criterion — flame detachment
in method T, the criterion of an explosion (self-propagating combustion) is the upward movement of the flame from the spark gap for at least 100 mm. This process which is referred to as "flame detachment" is visually observed (examples see annex A). If a halo reaches the top of the tube or has at least a height of 240 mm this shall be also counted as an ignition

NOTE During the duration of the ignition spark, test mixtures whose test substance content lies slightly outside the explosion range exhibit a luminous phenomenon (which is referred to as ”halo”) above the spark gap which does not, however, detach from the latter (see annex A). In the case of certain test substances (e.g. halogenated hydrocarbons), this luminous phenomenon occupies a large portion of the test vessel. The formation of an halo exclusively is not yet considered to be an ignition of the test mixture unless it reaches the top of the tube or a minimum height of 240 mm.

3.6
explosion criterion — pressure rise
in method B, the criterion of an explosion (self-propagating combustion) is the amount of the measured explosion overpressure. The test mixture is considered explosive if the measured explosion overpressure is equal to or greater than the overpressure created by the ignition source alone in air, plus (5 ± 0,1) % of the initial pressure

3.7
vapour
gaseous phase emanating or being emanated from a liquid. If not otherwise mentioned, the term ”gas” in this standard also includes such vapours but not mists

NOTE The special features of vapours (possible condensation, difference in mixture composition between liquid and vapour phase, change in mixture composition when taking out vapour phase from a closed volume) have to be considered carefully when determining explosion limits for vapours of flammable liquids.

3.8
oxidizer
air or an air/inert gas mixture (volume fraction of the oxygen ≤ 21 %)

3.9
sample
a substance or a mixture of substances for which explosion limits are to be determined

3.10
test substance
the sample in the gaseous state — in the case of liquid samples, after complete evaporation

3.11
test mixture
the mixture of test substance and air

4 Test Methods

4.1 Method T (”tube” method)

4.1.1 Principle

The test mixture is led through the cylindrical test vessel from below towards the top until the mixture being in the test vessel before has been completely replaced. Then in the quiescent test mixture an ignition is initiated using a series of induction sparks, and it is observed whether or not a flame detachment occurs. The test substance content of the test mixture is varied step by step until the *LEL* or the *UEL* (explosion criterion — flame detachment) have been determined or until it is certain that there exists no explosion range.

4.1.2 Reagents and Materials

- air: the air shall be free of water and oil. If synthetic air is used, it has to be stated in the report.
- inert gases: 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 substance: the flammable substance may be:
  - a single substance or a defined 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).

  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.
- heat-resistant, chemically inert material for gaskets and adhesive mountings.

Sample containers are to be kept closed before and after sampling to avoid alterations of the sample (e.g. escape of volatile constituents in the case of mixtures). If the sample consists of a gas mixture which is removed from a container containing a liquid phase, take into account that the composition of the gas and the liquid phase is different. It is recommended to take the test substance from the liquid phase.

4.1.3 Apparatus

4.1.3.1 General

The apparatus (see figure 1) consists of:

- test vessel;
- ignition source;
- equipment for preparing the test mixture;
- temperature regulating device;
- safety equipment.

4.1.3.2 Test vessel

The test vessel is an upright cylindrical test vessel made of glass or another transparent material (e.g. polycarbonate) with an inner diameter of (80 ± 2) mm and a minimum length of 300 mm. An inlet pipe for the test mixture with three-way cock, has to be placed at the bottom, an outlet pipe and pressure venting in the upper part.

Bottom and top may be made of other material. It has to be however free of any catalytic effect and resistant to corrosion by the test mixture as well as the reaction products.

4.1.3.3 Ignition source

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

The electrodes shall end (60 ± 1) mm above the bottom of the test vessel.

Stainless steel is a suitable material for the electrodes. The electrodes shall be pointed rods with a diameter of maximum 4 mm. The angle of the tips shall be (60 ± 3)°. The distance between the tips shall be (5 ± 0,1) mm. The electrodes shall be mounted in the vessel so that 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 up to 0,5 s.

The power of the induction sparks 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.

4.1.3.4 Equipment for preparing the test mixture

The test mixture is prepared by mixing flows of gaseous components. For doing so the following equipment is necessary:

- metering device for air, gaseous samples or additional inert gases (e.g. mass flow controller, volume flow controller, metering pump for gases);
- metering device for liquid samples (e.g. volumetric metering pumps);
- evaporator equipment in the case of a liquid sample (for example see annex B);
- mixing vessel for homogenizing the test mixture.

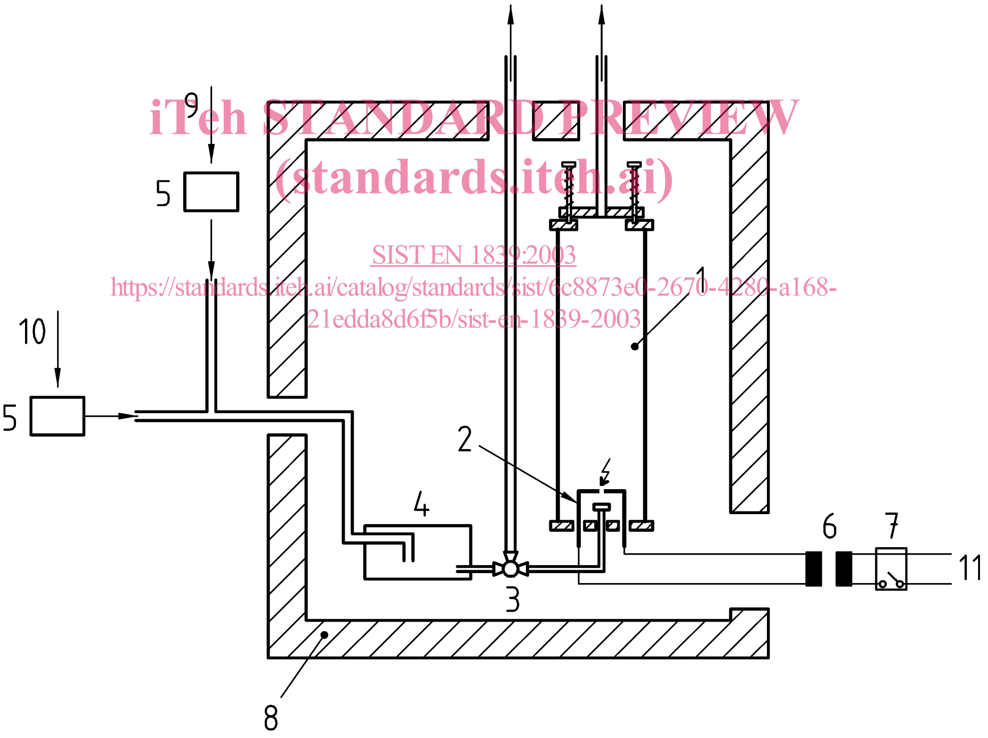
The metering devices and the equipment for preparing the test mixture has to be designed in such a way that the uncertainty of measurement of the test substance content in the test mixture is not higher then the data given in table 1.

Table 1 — Maximum permissible uncertainty of measurement for the amount of test substance in the test mixture

molar amount of test substance %	maximum uncertainty of measurement %	
	relative	absolute
≤ 2	± 10	
> 2		± 0,2

4.1.3.5 Temperature regulating device

For measurements at temperatures higher than ambient temperature, the apparatus has to be equipped with a temperature regulating device. In such a case it has to be ensured that the temperature difference inside the test vessel is not more than 10 K. This has to be proven when building up the apparatus and every time when parts are renewed and with every verification.



Key

1	test vessel	7	timer
2	electrodes	8	facility for keeping the temperature
3	three-way cock	9	flammable substance
4	mixing vessel	10	air
5	metering devices	11	power supply
6	high-voltage transformer		

Figure 1 — Scheme of the ‘tube’ apparatus for determining the explosion limits

4.1.3.6 Safety equipment

The safety advices according annex C have to be followed.

4.1.4 Preparation of the test mixture

When evaporating liquid samples, it has to be considered that the mixture composition of a gaseous phase in equilibrium with a liquid phase (”vapour”) generally differs from the mixture composition of the liquid phase. Also the mixture composition of the liquid and the vapour phase may change, when taking out substance from the vapour phase. This has to be observed carefully when determining explosion limits for flammable liquids, when handling liquid samples and when preparing test mixtures by evaporating liquid samples. To avoid mistakes, the method of dynamic total evaporation is to be used. An example for a recommended evaporator equipment is described in annex D. When liquids are metered, it has to be ensured that no bubbles form in any part carrying the liquid (e.g. pipes). To achieve complete homogenization, the test mixture is led through a mixing vessel, preferably made of glass. For a mixing vessel without built-in elements a volume of at least 600 ml is recommended. It is expedient to introduce the test mixture tangentially. The mixing vessel is not necessary if the homogenization is already ensured by the metering device. The temperature of the mixing vessel and of all parts carrying the test mixture is to be kept constant so that the test substance cannot condense. It is recommended to heat the parts carrying the test mixture together with the test vessel.

4.1.5 Procedure

If the explosion limits are determined at increased temperature, preheat the test vessel and all parts carrying the test mixture to the required temperature. For liquid samples the temperature of the test mixture shall be at least 25 K higher than the condensation temperature. Prior to each ignition attempt, it has to be ensured that the temperature in the test vessel differs not more than 5 K from the required value.

The determination of the explosion limits consists of a series of ignition attempts which are carried out with test mixtures whose test substance content is varied.

For safety reasons, the ignition attempts are started with a test substance content in the test mixture which lies, if possible, outside the explosion range to be expected.

NOTE Rough estimate of the amount of substance to start experiments:

For organic substances which consist exclusively of carbon, hydrogen and oxygen (with the exception of peroxides), the *LEL* can be roughly estimated. At 20 °C, the *LEL* is in many cases at approximately half the test substance content of the stoichiometric composition. The temperature dependence of the *LEL* has to be taken into account. Up to 200 °C, the *LEL* decreases more or less linearly between 30 % and 50 % of the value estimated for 20 °C.

There is at present no method which is easy to apply for estimating the *UEL*.

Prior to each ignition attempt, the test vessel is purged with the test mixture. The purging volume has to be at least ten times the volume of the test vessel. Subsequently, the test mixture by-passes the test vessel and is supplied into the exhaust system; the inlet to the test vessel is sealed. Then an ignition is attempted with the induction spark when test mixture is quiescent (6 s to 10 s), and it is observed whether a flame detaches from the ignition source (see annex A).

It is recommended not to interrupt the production of test mixture during the ignition attempts, as after any new start, it will take a certain time to produce a test mixture of constant composition even if the adjustment has not been changed.

If an ignition is observed, the test substance content in the test mixture is iteratively varied until no further flame detachment follows. Close to the explosion limits, the step size for the variation of the test substance content has to be selected such that it is at the most equal to the relative deviation given in table 1. The test mixture with which a further flame detachment just failed has to be used to carry out another four tests. The determination is terminated when all five tests have taken place without flame detachment. If this is not the case, the test substance content has to be varied again, i.e. for the determination of the *LEL* the test substance content has to be reduced by one step size; for the *UEL*, it has to be increased by one step size. Subsequently, another five tests are to be carried out. It is recommended to check the quantitative composition of the non-ignited test mixture flowing out of the test vessel in order to recognise in time maladjustments of the metering devices or leakage.