



SLOVENSKI STANDARD

oSIST prEN 17624:2021

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Določanje eksplozijskih mej plinov in hlapov pri povišanem tlaku, povišani temperaturi ali z oksidanti, ki niso sestavljeni iz zraka

Determination of explosion limits of gases and vapours at elevated pressures, elevated temperatures or with oxidizers other than air

Bestimmung der Explosionsgrenzen von Gasen und Dämpfen bei erhöhten Drücken, erhöhten Temperaturen oder mit Oxidationsmitteln, welche nicht aus Luft bestehen

Détermination des limites d'explosivité des gaz et vapeurs à pressions et températures élevées avec des oxydants autres que l'air

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ICS:

13.230 Varstvo pred eksplozijo Explosion protection

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

DRAFT
prEN 17624

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ICS 13.230

English Version

Determination of explosion limits of gases and vapours at elevated pressures, elevated temperatures or with oxidizers other than air

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This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 305.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CEN 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 CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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European foreword

This document (prEN 17624:2020) 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 document is currently submitted to the CEN Enquiry.

This document has been prepared under a standardization request given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) 2006/42/EC.

For relationship with EU Directive 2006/42/EC, see informative Annex ZA, which is an integral part of this document.

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prEN 17624:2020 (E)**Introduction**

In accordance with EN ISO 12100:2010, this is a type B standard.

The scope of EC Directive 2014/34 (ATEX) deals with explosive atmospheres of mixtures of flammable substances and air in the pressures range between 0,8 kPa and 1,1 kPa and the temperature range between -20 °C and 60 °C (atmospheric conditions). Therefore, the scope of the standards dealing with the determination of safety characteristic data, for which CEN gave a mandate with respect to EU Directive 2014/34 (ATEX), covers in general only such pressure and temperature conditions, and air as the only oxidizer.

Technical conditions in plants etc. may differ remarkably from the pressure and temperature range of the ATEX. Furthermore, explosive mixtures of flammable substances and oxidizers other than air are likely to occur.

Safety characteristic data may, however, depend remarkably on both pressure and temperature, and also the oxidizer.

The hazard of an explosion can be avoided by preventing the formation of explosive mixtures of gases and/or vapours with oxidizers. To do so, the explosion limits (also known as “flammability limits”) of the flammable substance at the respective non-atmospheric conditions need to be known.

To obtain reliable and comparable results it is necessary to standardize the conditions for determining the explosion limits at non-atmospheric conditions.

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1 Scope

This document specifies a test method to determine the explosion limits of gases, vapours and their mixtures, mixed with a gaseous oxidizer or an oxidizer/inert gas mixture at pressures from 1 bar to 100 bar and for temperatures up to 400 °C.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10156:2017, *Gas cylinders — Gases and gas mixtures — Determination of fire potential and oxidizing ability for the selection of cylinder valve outlets*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

flammable substance

substance in the form of gas, vapour or mixtures of these, able to undergo an explosive exothermic reaction with an oxidizer or an oxidizer/inert gas mixture when ignited

[SOURCE: EN 13237:2012, 3.37, modified]

3.2

explosion range

range of the concentration of a flammable substance or mixture of substances with an oxidizer, within which an explosion can occur determined under specified test conditions

Note 1 to entry: The explosion limits are not part of the explosion range.

[SOURCE: EN 13237:2012, 3.22, modified]

3.3

lower explosion limit

LEL

lowest concentration of the explosion range

Note 1 to entry: Those concentrations are given at which an explosion just fails during the tests.

[SOURCE: EN 13237:2012, 3.19.1, modified]

prEN 17624:2020 (E)**3.4
upper explosion limit
UEL**

highest concentration of the explosion range

Note 1 to entry: Those concentrations are given at which an explosion just fails during the tests.

[SOURCE: EN 13237:2012, 3.19.2, modified]

**3.5
inert gas**
gas that does not react with the test substance or oxidizer**3.6
explosion criterion**
either an explosion pressure p_{ex} relative to the initial pressure (p_i) as follows (considering the overpressure that is created by the ignition source alone (p_{IS})):

$$p_{\text{ex}}/p_i \geq (1,05 + p_{\text{IS}}/p_i - 1) \text{ for initial pressures } p_i \leq 2)$$

$$p_{\text{ex}}/p_i \geq (1,02 + p_{\text{IS}}/p_i - 1) \text{ (for initial pressures } p_i > 2)$$

or a temperature rise (ΔT) of at least 100 K

**3.7
oxidizer**

any oxidising gas except highly reactive oxidisers with oxidizing potentials according to EN ISO 10156:2017 higher than oxygen, e.g. ozone, fluorine, fluorinated compounds etc.

**3.8
sample**
substance or mixture of substances for which explosion limits are to be determined**3.9
test substance**
sample in the gaseous state; in the case of liquid samples, after complete evaporation**3.10
test mixture**
mixture of test substance and air or air/inert gas**4 Test methods****4.1 General**

The determination consists of a series of ignition tests which are carried out with test mixtures varying the test substance content.

The quiescent test mixture in the closed vessel is subjected to an ignition source. The overpressure and the temperature rise as a result of the ignition is measured and characterizes the explosivity of the test mixture. The amount of test substance in the test mixture is varied incrementally until the *LEL* or the *UEL* is determined, or until it is ascertained that there is no explosion range.

When it is established that a given test mixture will not ignite, it is recommended to analyse the quantitative composition of the non-ignited test mixture flowing out of the test vessel in order to ensure that no errors occurred either with the metering devices, or due to leakage.

NOTE 1 For organic substances consisting exclusively of carbon, hydrogen and oxygen (with the exception of peroxides), the starting composition of the mixture to determine the *LEL* in air and oxygen can be roughly estimated. For other oxidizers there is currently no estimation method available.

NOTE 2 At 20 °C, the *LEL* in air, in many cases, is approximately half the test substance content of the stoichiometric composition **in air**. At 20 °C, the *LEL* in oxygen is similar to that in air. The temperature dependence of the *LEL* has to be taken into account. Up to 200 °C resp. up to temperatures near to the auto-ignition temperature, the *LEL* in air and oxygen decreases more or less linearly up to 50 % of the value estimated for 20 °C.

NOTE 3 Currently, neither for ambient conditions, nor for non-ambient conditions is there a method available for readily estimating the UEL. However, the UEL rises remarkably with increasing temperature, increasing pressure or oxidizing potential of the oxidizer.

4.2 Reagents and materials

4.2.1 Sample

The sample is either a single substance or a defined mixture of substances, or a process sample (of known, or unknown composition).

When a single substance, or a defined 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, its composition (including the scatter) shall be stated in the test report. In the case of a process sample of unknown composition, the sample shall be defined as precisely as is possible e.g. by process conditions.

Sample containers shall be kept closed before and after sampling to avoid changes in the sample composition (e.g. loss of volatile components from mixtures).

4.2.2 Oxidizer

The oxidizer shall be free of water ($\leq 0,1$ mol% water vapour absolute) and oil ($\leq 0,1$ g/m³ oil).

If synthetic air is used, it shall be stated in the report.

4.2.3 Inert gases

The purity of the inert gas or the mixture of inert gases, shall be 99,8 mol%, or better.

If a mixture of inert gases is used, the composition of the mixture shall be stated in the test report.

4.2.4 Gaskets and mountings

In oxygen enriched mixtures it is absolutely necessary to take care that the materials of the gaskets and mountings are not of organic origin and that they are oil and grease free to avoid accidents.

Special care shall be taken in the case of corrosive oxidizers or corrosive flammable substances.

4.3 Apparatus

4.3.1 Test vessel

The test vessel shall be cylindrical or spherical. If a cylindrical vessel is used, the length to diameter ratio shall be between 1,0 and 1,5. The minimum internal volume of the test vessel depends on the initial pressure in the tests and shall be according to the following Table 1.

Table 1 — Fundamental requirements of the apparatus

Initial Pressure (p_i)	Minimum internal volume of the test vessel	Ignition source
$1 \text{ bar} \leq p_i < 5 \text{ bar}$	10 dm ³	exploding wire
	5 dm ³	induction spark, surface-gap spark
$5 \text{ bar} \leq p_i < 50 \text{ bar}$	3 dm ³	surface-gap spark up to 25 bar, exploding wire
$p_i \geq 50 \text{ bar}$	1 dm ³	exploding wire

The test vessel and any equipment (valves, ignition source, pressure and temperature sensors etc.) fitted to the vessel shall be designed to withstand a maximum overpressure of at least 15 times the initial pressure if air is the oxidizer. For mixtures with an oxidizer having an oxidizing potential according to EN ISO 10156:2017 higher than air, the test vessel and the equipment shall be designed to withstand a maximum overpressure of at least 30 times the initial pressure.

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. It has to be grounded.

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

It has to be equipped with an ignition source, a temperature and pressure measuring system to set the initial pressure and temperature and a temperature and pressure measuring system to measure the generated temperature rise and overpressure after ignition.

4.3.2 Measurement system to adjust the initial pressure and temperature

4.3.2.1 Initial pressure

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The pressure measuring system may contain a piezoresistive pressure transducer. If the test mixture is prepared inside the test vessel by partial pressures using this pressure transducer then it shall be calibrated. It is recommended that this pressure measuring system is disconnected, via a valve to protect it, during the ignition trials.

4.3.2.2 Initial temperature

The temperature measuring system consists of a sheath thermocouple and recording equipment. The thermocouple shall have a limit deviation of not more than 1,5 K. The diameter of the thermocouple shall not exceed 1,5 mm. It is recommended that the diameter of this thermocouple is larger than that of the thermocouple used to detect the temperature rise because comparison of the starting temperature with both temperature measuring systems may indicate any fault of the temperature measuring system to measure the generated temperature rise.

4.3.2.3 Explosion overpressure measurement system

The pressure measuring system for detecting the overpressure after ignition shall contain a piezoelectric or piezoresistive pressure transducer. If the head of the pressure transducers is not flush to the internal wall the maximum distance between the head of the pressure transducer and inner surface shall be 100 mm.

The pressure transducers shall have a resonance frequency greater than 30 kHz.

The pressure measurement system shall have an accuracy that allows the explosion overpressure to be measured in accordance with the explosion criterion (see 3.6). It shall have a resolution of at least 10^{-4} of full scale.

4.3.2.4 Measurement system to measure the temperature rise

The temperature measuring system consists of a sheath thermocouple and recording equipment. The thermocouple shall be mounted inside the vessel above the ignition source with a distance of $10 \text{ mm} \pm 1 \text{ mm}$ from the top of the vessel. Its diameter shall be 0,5 mm.

By comparison of the starting temperature with both temperature measuring systems any fault of the temperature measuring system to measure the generated temperature rise can be detected.

4.3.3 Ignition source

The ignition source shall be positioned above the bottom of the test vessel. Suitable types of an ignition source are either a series of induction sparks, a surface gap spark or an exploding wire. In the test report, the type of ignition source used shall be stated.

4.3.3.1 Induction spark

This ignition source may be used for initial pressures up to 5 bar.

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

The electrodes shall end $(50 \pm 1) \text{ mm}$ 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 3,0 mm. The angle of the tips shall be $(60 \pm 3)^\circ$. The distance between the tips shall be $(5 \pm 0,1) \text{ mm}$. 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 the 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 induction sparks is dependent on the gas mixture and its pressure. In air at atmospheric conditions, according to calorimetric and electric measurements, such an arrangement gives a power of approximately 10 W.

Fluorinated substances, e.g. SF₆, CF₄ etc., can suppress induction sparks. In such cases an ignition source according to 4.3.3.2 or 4.3.3.3 shall apply.

4.3.3.2 Surface-gap spark

This ignition source may be used for initial pressures up to 25 bar.

An electric arc which is generated by passing an electric charge along the straight length of a graphite rod connected between two metal rods is used as the ignition source.

The metal rods shall end $(50 \pm 1) \text{ mm}$ above the bottom of the test vessel.

The electrical power necessary to generate the arc is supplied by a capacitive discharge or an isolating transformer. If the arc is generated by using capacitive discharge the ignition energy delivered by the arc depends on the capacity and charging voltage.