



SLOVENSKI STANDARD
SIST EN 17624:2022

01-september-2022

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

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This European Standard was approved by CEN on 7 February 2022.

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

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European foreword

This document (EN 17624:2022) 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of an identical text or by endorsement, at the latest by September 2022, and conflicting national standards shall be withdrawn at the latest by September 2022.

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

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EN 17624:2022 (E)**Introduction**

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

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 need to be known. These limits are a strong function of the pressure and temperature within the system.

Standard EN 1839:2017 has methods suitable for determining these limits at atmospheric conditions. Technical conditions in plants, etc. can differ substantially from these assumed atmospheric conditions. Furthermore, explosive mixtures of flammable substances and oxidizers other than air are likely to occur.

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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SIST EN 17624:2022

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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 0,10 MPa to 10 MPa 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.

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

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 <https://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: removed reference to liquids and solids as they are not relevant for this standard]

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, respectively range of the concentration of a flammable substance or mixture of substances in mixture with oxidizer/inert gas, 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: changed air to oxidizer]

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: removed “at which an explosion can occur”]

EN 17624:2022 (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: removed “at which an explosion can occur”]

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})):

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

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

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 oxidizer or oxidizer/inert gas

3.11**mole fraction**

$x(S)$

mole fraction given in percent

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. 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.

NOTE 2 The *LEL* is dependent on temperature. From ambient temperature the *LEL* in both air and oxygen decreases more or less linearly with increasing temperature up to temperatures near the autoignition temperature, where the relationship becomes non-linear. Where the relationship is still linear the *LEL* usually decreases by between 5 % and 30 % per 100 K of temperature rise.

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 specified mixture of substances, or a process sample (of known, or unknown composition).

When a single substance, or a specified mixture of substances, is used, the purity of each substance shall be $x(S) = 99,8 \%$, 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 ($x(S) \leq 0,1 \text{ mol\%}$, as water vapour) and oil ($\leq 0,1 \text{ g/m}^3$ 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 $x(S) = 99,8 \%$, or better.

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

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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
$0,1 \text{ MPa} \leq p_i < 0,5 \text{ MPa}$	10 dm ³	exploding wire
	5 dm ³	induction spark, surface-gap spark
$0,5 \text{ MPa} \leq p_i < 5 \text{ MPa}$	3 dm ³	surface-gap spark up to 2,5 MPa, exploding wire
$p_i \geq 5 \text{ MPa}$	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

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 ± 1) 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

4.3.3.1 General

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.

4.3.3.2 Induction spark

This ignition source may be used for initial pressures up to 0,5 MPa.

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

The electrodes shall end (50 ± 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 3,0 mm. The angle of the tips shall be $(60 \pm 3)^\circ$. The distance between the tips shall be $(5 \pm 0,1)$ 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 voltage 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.