Determination of explosion characteristics of dust clouds —

Part 1: Determination of the maximum explosion pressure $\rho_{\text{max}}$ of dust clouds
National foreword

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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;
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Summary of pages
This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 27 and a back cover.

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Determination of explosion characteristics of dust clouds - Part 1: Determination of the maximum explosion pressure $p_{\text{max}}$ of dust clouds

This European Standard was approved by CEN on 9 July 2004.

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Foreword

This document (EN 14034-1:2004) 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of an identical text or by endorsement, at the latest by March 2005, and conflicting national standards shall be withdrawn at the latest by March 2005.

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.

This document includes a Bibliography.

This document is one of a series of standards as listed below:

— EN 14034-1, Determination of explosion characteristics of dust clouds - Part 1: Determination of the maximum explosion pressure $p_{\text{max}}$ of dust clouds;
— prEN 14034-2, Determination of explosion characteristics of dust clouds - Part 2: Determination of the maximum rate of explosion pressure rise $(dp/dt)_{\text{max}}$ of dust clouds;
— prEN 14034-3, Determination of explosion characteristics of dust clouds – Part 3: Determination of the lower explosion limit LEL of dust clouds;
— EN 14034-4, Determination of explosion characteristics of dust clouds – Part 4: Determination of the limiting oxygen concentration LOC of dust clouds.

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 document specifies a method for experimental determination of the maximum explosion pressure of dust clouds. The maximum explosion pressure is the maximum value of the overpressure during explosions of explosive atmospheres in the explosion range of a combustible dust in a closed vessel. The measurement of the maximum explosion pressure forms the basis for explosion protection by design and construction of equipment, protective systems and components to reduce the explosion effects.

This maximum explosion pressure is a safety characteristic used for hazard identification and designing safety measures for the mitigation of destructive effects of dust explosions.

Therefore this document gives added values to the following clauses of the EU directives:


  Annex I, Clause 1.5.7


  Annex II, Clause 1.0.1
1 Scope

This document describes a test method for the determination of the maximum explosion pressure of dust clouds in a closed vessel under defined initial conditions of pressure and temperature.

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

2 Normative references

The following referenced documents are indispensable for the application 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.

prEN 14460, Explosion resistant equipment.

3 Terms and definitions

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

3.1 dust
small solid particles in the atmosphere which settle out under their own weight, but which may remain suspended in air for some time (includes dust and grit, as defined in ISO 4225)

NOTE Generally maximum particle size will not exceed 500 µm.

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

NOTE The terms “flammable” and “combustible” are used synonymously.

3.3 explosion pressure
\( p_{\text{ex}} \)
the highest overpressure occurring during an explosion of a dust cloud in a closed vessel

3.4 explosive atmosphere
mixture with air, under atmospheric conditions, of flammable (combustible) substances in the form of gases, vapours, mists or dusts, in which, after ignition has occurred, combustion spreads to the entire unburned mixture

3.5 ignition delay
\( t_i \)
time between the initiation of the dust dispersion and the activation of the ignition source

3.6 initial pressure
\( p_i \)
the pressure in the explosion vessel at the moment of ignition
3.7
initial temperature
\( T_i \)
the temperature in the explosion vessel at the moment of ignition

3.8
maximum explosion pressure
\( p_{\text{max}} \)
maximum overpressure occurring in a closed vessel during the explosion of an explosive atmosphere determined under specified test conditions and standard atmospheric conditions. (Maximum value of the explosion pressure \( p_{\text{ex}} \) determined by tests covering the explodable range of dust concentrations).

4 Test apparatus

4.1 General

The standard test apparatus to determine the maximum explosion pressure \( p_{\text{max}} \) of dust clouds is an explosion pressure resistant vessel of 1 m³, as used for the determination of the maximum rate of explosion pressure rise \( (K_{\text{St}}\text{-value}) \) and the lower explosion limit of dust clouds as well as the limiting oxygen concentration of dust/air/inert gas mixtures.

The main components of the test apparatus are

- explosion vessel;
- dust dispersion system;
- ignition source;
- control unit;
- pressure measuring system.

NOTE The 20 l sphere apparatus is an alternative explosion vessel for these determinations (see annex C)

4.2 Explosion vessel

The standard explosion vessel is an explosion pressure resistant, spherical or cylindrical vessel in accordance with prEN 14460 having a volume of 1 m³. The aspect ratio of the cylindrical vessel shall be 1:1 ± 10 % (see Figure 1).

NOTE It is recommended that the explosion vessel be designed to withstand an overpressure of at least 20 bar.

The apparatus shall be fitted with electrical and/or mechanical cut-offs as far as possible to ensure that any openings in the vessel (e.g. main door, instrument ports, inlet or outlet) are properly closed before a test procedure can start.

The apparatus shall also be equipped as far as possible to ensure that any residual pressure inside the vessel is vented before the vessel can be opened.
Figure 1 — 1 m³ vessel (schematic)
4.3 Dust dispersion system (dust container, fast acting valve, connecting tube, dust disperser)

The dust to be dispersed is charged into a dust container having a volume of 5,4 dm³. Its aspect ratio is 3:1. It is designed to withstand an internal overpressure of at least 20 bar (see Figure 2).

The dust container has an outlet at the base, through which the dust leaves the container. This outlet is closed by a fast acting valve activated by a blasting cap. The valve has a mushroom-shaped seal. The seal is held in position against the pressure in the dust container by a small ring. The ring is destroyed by firing a blasting cap and the valve opens due to the pressure inside the dust container (see Figure 2). The valve shall be designed so that it opens in less than 10 ms. For alternative valves see annex A.

The fast acting valve is connected to the side of the explosion vessel. The connecting tube between the fast acting valve and the dust disperser shall be not longer than 350 mm (see Figure 1).

For dispersing the dust, a perforated semicircular spray pipe (dust disperser) is mounted inside the explosion vessel, concentric with its wall. The spray pipe, with an internal diameter of 21,7 mm is fitted with 13 holes of a diameter of 6 mm (incl. one hole in each end cap) which shall be located as shown in Figure 3 (see also Figure 1).

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Key

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<td>2</td>
<td>Mushroom shaped seal</td>
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<td>3</td>
<td>Seal housing</td>
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<td>7</td>
<td>Blasting cap</td>
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<td>8</td>
<td>Connecting tube</td>
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Figure 2 — Dust container with blasting cap activated valve as commonly used for explosion suppression (schematic; it is commercially available)

For dispersing the dust, a perforated semicircular spray pipe (dust disperser) is mounted inside the explosion vessel, concentric with its wall. The spray pipe, with an internal diameter of 21,7 mm is fitted with 13 holes of a diameter of 6 mm (incl. one hole in each end cap) which shall be located as shown in Figure 3 (see also Figure 1).

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1 (e. g. EN ISO 1127, DN 20, ¾”)
For coarse, voluminous, fibrous or poorly flowing dust samples, it may not be possible to properly discharge the dust through the dust dispersers detailed in Figures 3 and B.1. It may, therefore, be necessary to use special dust dispersers, examples of which are given in Figures B.2 and B.3. In such cases, the dust disperser used shall be described in the test report.

NOTE If other dust dispersing systems than those described in this standard are used, a propagation of the explosion from the explosion vessel into the dust container, cannot be excluded. For this case, additional safety measures should be employed, e.g. higher pressure resistance of the dust container.

**Figure 3 — Location of the 6 mm holes in the dust disperser**

**Key**

1. 6 mm hole
2. End cap with 6 mm hole
4.4 Ignition source

The ignition source comprises two chemical igniters each having an energy of 5 kJ. The total mass of each igniter is 1.2 g and consists of 40 % by weight zirconium metal, 30 % by weight barium nitrate, and 30 % by weight barium peroxide. The igniters are fired by electrical fuse heads. The power supply circuit for the chemical igniters shall be capable of firing the fuse heads in less than 10 ms. The two chemical igniters shall be placed at the centre of the explosion vessel, firing in opposite directions (see Figure 1).

NOTE Chemical igniters are commercially available.

4.5 Control unit

The control unit sequences the start of the dust injection, the activation of the ignition source and the start of the recording system.

4.6 Pressure measuring system

The pressure measuring system includes at least two pressure sensors and recording equipment. The pressure sensors shall be fitted in the test vessel, with their heads flush with the internal wall. Precautions to prevent temperature effects on the pressure sensors shall be taken.

The pressure measuring system shall have an accuracy of ± 0.1 bar or better and a time resolution of 1 ms or better.

5 Dust sample

The maximum explosion pressure increases with decreasing particle size. Therefore the particle size distribution shall be determined for the sample as tested and given in the test report.

The maximum explosion pressure increases with decreasing moisture content. Therefore the moisture content shall be determined for the sample as tested and given in the test report.

NOTE 1 The size of the dust particles can be reduced by the dispersion process. In cases, where this effect may be important, its magnitude can be evaluated by determining the particle size distribution once more after dispersion (without ignition).

NOTE 2 A rough classification of the shape of the dust particles may be also required ("spherical","flat" or "fibrous").

NOTE 3 A volatile content may affect the explosion characteristics of the dust. In these circumstances it may be necessary to measure the volatile content.
6 Test procedure

Explosion tests with defined dust/air mixtures shall be carried out according to the following procedure.

The required amount of the dust is placed in the dust container. The container is then pressurised to an overpressure of 20 bar.

Before starting the test procedure the temperature inside the vessel shall be measured and recorded.

At the commencement of the dust dispersion the pressure in the 1 m³ vessel shall be at atmospheric pressure. The actual pressure in the 1 m³ vessel at the moment of ignition (initial pressure \( p_i \)) shall be measured and recorded.

The bulk volume of the dust shall not exceed \( \frac{3}{4} \) of the dust container allowing proper pressurisation. If this cannot be achieved, two dispersion systems with 5,4 dm³ dust containers shall be used in parallel.

The delay between the initiation of the dust dispersion and activation of the ignition source (ignition delay \( t_v \)) shall be \((0,6 \pm 0,01)\) s. The pressure is recorded as a function of time. From the pressure/time curve the explosion pressure \( p_{ex} \) is determined by taking the arithmetic mean of the values measured by the pressure sensors (see Figures 4 and 5).

If the difference in the pressures measured by the pressure sensors is more than 10 %, the accuracy of the sensors shall be checked and the measurements repeated.

An ignition of the dust (dust explosion) shall be considered to have taken place, when the measured overpressure relative to the initial pressure \( p_i \) is \( \geq 0,3 \) bar \([p_{ex} \geq (p_i + 0,3 \text{ bar}])\).

After each test, the explosion vessel shall be cleaned.

This procedure shall be repeated for a range of dust concentrations. Starting with a concentration of 250 g · m\(^{-3}\) the concentration shall be increased by steps of 250 g · m\(^{-3}\) or decreased by steps of 50 % of the preceding concentration according to the series shown below:

\[ ... ; 60; 125; 250; 500; 750; 1000; 1250; 1500; ... \text{ g} \cdot \text{m}^{-3} \]

Determine the explosion pressure \( p_{ex} \) for each concentration and plot \( p_{ex} \) against dust concentration until a maximum value of \( p_{ex} \) is found.

Determinations shall be made for a minimum of two successive concentrations on both sides of the maximum value. This maximum value is the maximum explosion pressure \( p_{max} \) (see Figure 5).

If this procedure does not give a definite maximum value, the test series shall be repeated at least once in the range of the maximum value of the explosion pressure. In such cases the arithmetic mean of the maximum values of each test series shall be taken as the maximum explosion pressure \( p_{max} \).
**Key**

- **Y1**: Overpressure in the dust container
- **Y2**: Explosion overpressure in the 1 m³ vessel
- **t_a**: Initiation of the fast acting valve
- **t_r**: Start of the dust dispersion
- **t_t**: Reaction time of the fast acting valve
- **t_i**: Release time of the dust container into the 1 m³ vessel without dust
- **t_r**: Escape time of pressurized air (without dust) from the dust container into the 1 m³ vessel
- **t_i**: Activation of the ignition source
- **t_r**: Ignition delay (0.6 ± 0.01) s

**Figure 4 — Dust dispersion and pressure-time curve (schematic)**
Key

Y1 Explosion overpressure \( p \)
Y2 Explosion overpressure \( p_{\text{ex}} \) in bar
X1 Time \( t \)
X2 Dust concentration \( C \) in g \( \cdot \) m\(^{-3} \)

Figure 5 — Determination of the maximum explosion pressure \( p_{\text{max}} \)

7 Calibration and verification

7.1 Calibration

Only calibrated systems for measuring temperature, time and pressure shall be used.
7.2 Verification

The test apparatus and the procedure shall be verified every 12 months, or following any significant maintenance or repair. The verification procedure described below covers the dust dispersing system and makes use of the maximum explosion pressure $p_{\text{max}}$.

Verification shall be carried out using the test procedure given in clause 6 by one of the following two ways:

— Internal verification with at least one reference dust for which the maximum explosion pressure $p_{\text{max}}$ is known. The results of $p_{\text{max}}$ shall not deviate by more than 5% from the results previously obtained with the reference dust;

— External verification by comparative measurement of the maximum explosion pressure $p_{\text{max}}$ with at least one other laboratory with at least one reference dust. The results of $p_{\text{max}}$ shall not deviate by more than 10% from the results previously obtained by the other laboratory.

For the purpose of internal verification reference dusts shall be chosen on the basis of evidence that their $p_{\text{max}}$ does not change significantly over the period between verifications.

8 Safety precautions / instructions for use

The instructions for use shall include at least the following warnings:

— Precautions shall be taken to prevent accidental ignition by electrostatics, friction, impact or other means during the handling of the dust samples, blasting caps and chemical igniters;

— Precautions shall be taken to ensure any openings in the explosion vessel, e.g. doors and ports, are properly closed before a test;

— Precautions shall be taken to ensure that if the explosion vessel did fail during a test personnel are protected from the flying fragments produced, either by use of shielding or by location at a safe distance;

— Before opening the explosion vessel any build up of internal pressure in the vessel shall be released;

— Glowing material may be left adhering to the walls of the explosion vessel after a test. Precautions shall be taken to ensure that if this material bursts into flame when the vessel is opened personnel are not put at risk;

— Toxic samples and reaction products shall be handled and disposed of in a way that will not cause harm to personnel or the environment.
9 Alternative test equipment / procedures

The maximum explosion pressure $p_{\text{max}}$ of dust clouds can be determined using alternative test equipment and/or test procedures. When using an alternative it shall be shown that at least for the following dusts

- 20 different dusts with $(dp/dt)_{\text{max}}$ in the range of $> 0 \text{ bar} \cdot \text{s}^{-1}$ to 200 bar · s$^{-1}$ (St 1),
- 10 different dusts with $(dp/dt)_{\text{max}}$ in the range of $> 200 \text{ bar} \cdot \text{s}^{-1}$ to 300 bar · s$^{-1}$ (St 2),
- 5 different dusts with $(dp/dt)_{\text{max}}$ in the range of $> 300 \text{ bar} \cdot \text{s}^{-1}$ (St 3)

the method yields results that do not deviate by more than 10% from the results obtained using equipment or procedure described in this standard. The dusts used shall include at least two metal powders, two natural organic powders, two synthetic organic powders and two coal dusts.

Details of an alternative method using the 20 l sphere, for which conformity has been proven, are given in annex C.

10 Test report

The test report shall include at least the following information:

- Name and address of the testing laboratory;
- Unique identification of the test report;
- Name, description and identification of the tested dust (characteristics);
- Preparation of the dust sample for the tests;
- Particle size distribution of the tested dust (incl. method);
- Moisture content of the tested dust (incl. method);
- If relevant a volatile content of the tested dust (incl. method);
- Type of the test equipment and test procedure used;
- Any changes to the test equipment or test procedures specified in this standard, the reasons for the changes and any other information relevant to specific tests;
- Initial temperature $T_i$;
- Initial pressure $p_i$;
- A table or graph showing the measured values of $p_{\text{ex}}$ versus the dust concentration (corresponding to Figure 5);
- Maximum explosion pressure $p_{\text{max}}$, given as overpressure in bar (see 3.8);
- A statement to the effect that the test results relate only to the samples tested;
- A statement that the result may deviate up to 10%.
Annex A  
(normative)

Electro pneumatic valve

An alternative type of fast acting valve for which conformity has been proven, is the:

**Electro pneumatic valve**

A ball valve with an electro pneumatic drive (see Figure A.1) can be used instead of the fast acting valve described in 4.3. It shall be designed to withstand an internal overpressure of at least 20 bar. The opening time shall be < 100 ms. Valves meeting these requirements are commercially available.

Dimensions in millimetres

![Electro pneumatic valve](image)

**Key**

1 Dust container  
2 Electro pneumatic valve, DN 25  
3 1” elbow, internal diameter: 27.7 mm  
4 Explosion vessel

*Figure A.1 — Electro pneumatic valve (schematic)*
One indication of conformity is a dispersion characteristic lying between the ranges given in Figure A.2 (without dust).

![Graph showing discharge characteristic of dust dispersers (without dust).](image)

**Key**

1. Blasting cap activated valve
2. Electro pneumatic valve

**Figure A.2 — Discharge characteristic of dust dispersers (without dust)**

For conformity the delay between the initiation of the dust dispersion (by activating the electro pneumatic valve) and activation of the ignition source shall be in the range of \((0.6 \pm 0.1)\) s. The value \((x)\) for the ignition delay time \((t_v = (x \pm 0.01)\) s) shall be determined by an external verification according to 7.2.
Annex B
(normative)

Dust disperser with 5 mm holes

An alternative type of semicircular dust disperser for which conformity has been proven, is the:

Dust disperser with 5 mm holes

This dust disperser, with an internal diameter of 21.7 mm (see 4.3) is fitted with 20 holes of a diameter of 5 mm (incl. one hole in each end cap) which are located according to Figure B.1.

NOTE 1 The dust disperser nozzles have been developed in Europe over many years. For historical reasons the size and number of holes in the pipes in current use vary somewhat. The two configurations specified in the standard and in this annex have been proven to yield practically identical results.

NOTE 2 For coarse, voluminous, fibrous or poorly flowing dust samples, it may not be possible to properly discharge the dust through the dust dispersers detailed in Figures 3 and B.1. It may, therefore, be necessary to use special dust dispersers, examples of which are given in Figures B.2 and B.3. In such cases, the dust disperser used should be described in the test report.
Key

1  End cap with 5 mm hole

Figure B.1 — Location of the 5 mm holes in the dust disperser
Figure B.2 — Rebound nozzle
Figure B.3 — Dispersion cup
Annex C
(normative)

20 l sphere

C.1 General

An alternative type of test equipment, for which conformity has been proven, is the:

20 l sphere

Limits of applicability

For coarse, voluminous, fibrous or poorly flowing dusts, it may not be possible to properly discharge the dust through the dispersing system described in this annex. In that case, the 1 m³ vessel shall be used (as far as possible).

C.2 Test apparatus

The explosion vessel is an explosion resistant hollow sphere in accordance with prEN 14460 made of stainless steel, with a volume of 20 dm³. A water jacket serves to dissipate the heat from the explosions. For testing, the dust is dispersed into the sphere from a pressurised dust container via the fast acting valve and a rebound nozzle. The fast acting valve is pneumatically opened and closed by means of an auxiliary piston. The valves for the compressed air are activated electrically. The ignition source is located in the centre of the sphere. The pressure measuring system includes at least two pressure sensors, recording and control equipment (see Figure C.1).

Prior to dispersing the dust the sphere shall be partially evacuated to a pressure of 0.4 bar so after dust injection the pressure in the sphere (initial pressure $p_i$) is equal to 1013 mbar.

C.3 Test conditions

— Dispersion overpressure $p_z = 20$ bar;
— Initial pressure $p_i = 1013$ mbar (pre-evacuation of the explosion vessel down to 0.4 bar);
— Initial temperature $T_i = 20 \degree C$ (water cooling);
— Ignition delay time $t_v = 60$ ms;
— Ignition source = two chemical igniters each having an energy of 5 kJ.
C.4 Test procedure

In general the test procedures described for the 1 m³ vessel (see clause 6) shall be applied for the 20 l sphere.

An ignition of the dust has taken place, when the measured overpressure (influence of chemical igniters included) relative to the initial pressure $p_i$ is $\geq 0.5$ bar [$p_{ex} \geq (p_i + 0.5\text{ bar})$].

In the first test series, the explosion pressure is determined over a range of concentrations. Starting with a concentration of 250 g · m⁻³ the concentration should be increased by steps of 250 g · m⁻³ or decreased by steps of about 50 % of the preceding concentration according to the series shown below:

... 60; 125; 250; 500; 750; 1000; 1250; 1500; ... g · m⁻³

Determine the explosion pressure $p_{ex}$ for each concentration and plot $p_{ex}$ against dust concentration until a maximum value of $p_{ex}$ is found. Determinations shall be made for a minimum of two successive concentrations on both sides of the maximum value. This maximum value is considered the maximum explosion pressure $p_{max}$.[series 1].

Subsequently, two further test series, as described above, shall be carried out.
C.5 Calculation and correction of $p_{\text{max}}$

The maximum explosion pressure determined in closed, spherical or cubic vessels of sufficient size ($V \geq 20 \text{ dm}^3$) with central ignition source, is practically independent of the volume of the vessel.

The maximum explosion pressure, determined in the 20 l sphere $p_{\text{max},20\text{l}}$ is defined as the arithmetic mean of the maximum values of the explosion pressure $p_{\text{max}}$ of each series as follows:

$$
\frac{p_{\text{max},20\text{l}}}{\text{bar}} = \frac{p_{\text{max},[\text{series}\,1]} + p_{\text{max},[\text{series}\,2]} + p_{\text{max},[\text{series}\,3]}}{3}
$$

(C.1)

Correction of the measured explosion pressure $p_{\text{max},20\text{l}} \geq 5.5 \text{ bar}$

Due to cooling effects a correction shall be made according to the following equation:

$$
\frac{p_{\text{max}}}{\text{bar}} = 0.775 \cdot \frac{p_{\text{max},20\text{l}}}{\text{bar}}^{1.15}
$$

(C.2)

Correction of the measured explosion pressure $p_{\text{max},20\text{l}} < 5.5 \text{ bar}$

Due to the small volume of the 20 l sphere, the pressure effect caused by the chemical igniters shall be taken into account according to the following equation:

$$
\frac{p_{\text{max}}}{\text{bar}} = \frac{5.5 \cdot (p_{\text{max},20\text{l}} - p_{ci})}{(5.5 - p_{ci})}
$$

(C.3)

$$
\frac{p_{ci}}{\text{bar}} = \frac{1.6 \cdot E_i}{10000}
$$

(C.4)

where:

$p_{ci}$ pressure due to chemical igniters in bar;

$E_i$ ignition energy in J.
Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 94/9

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 94/9/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

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


