BS EN 15967:2011

BSI Standards Publication

Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours

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National foreword

This British Standard is the UK implementation of EN 15967:2011. It supersedes BS EN 13673-1:2003 and BS EN 13673-2:2005, which are withdrawn.

This standard determines the maximum explosion pressure and maximum rate of pressure rise for gases and vapours under standardized conditions at ambient temperature, pressure and from quiescent initial conditions. Any variation from experimental conditions in temperature, pressure or turbulence will lead to discrepancy between observed values and those determined through experiment. In particular, increased levels of turbulence above those seen in the experimental equipment, initiating explosions from pressures above ambient and effects such as pressure piling will lead to enhanced pressure generation and rates of pressure rise when compared to experimental values.

The UK participation in its preparation was entrusted to Technical Committee EXL/23, Explosion and fire precautions in industrial and chemical plant.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Determination of maximum explosion pressure and the maximum rate of pressure rise of gases and vapours

Détermination de la pression maximale d'explosion et de la vitesse maximale de montée en pression des gaz et des vapeurs

Verfahren zur Bestimmung des maximalen Explosionsdruckes und des maximalen zeitlichen Druckanstieges für Gase und Dämpfe

This European Standard was approved by CEN on 1 July 2011.

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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre has the same status as the official versions.

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Contents

Page

Figures

Tables

Foreword

This document (EN 15967:2011) 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 February 2012, and conflicting national standards shall be withdrawn at the latest by February 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13673-1:2003, EN 13673-2:2005.

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 and B which are an integral part of this document.

The significant changes between this European Standard and EN 13673-1:2003 and EN 13673-2:2005 are given in Table G.1

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

Introduction

This European Standard describes test methods for the determination of:

- the explosion pressure and the maximum explosion pressure; and
- 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.

Maximum explosion pressure 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 maximum explosion pressure and the maximum rate of explosion pressure rise are determined.

1 Scope

This European Standard specifies a test method that is designed to produce measurements of explosion pressure and the maximum explosion pressure, the rate of explosion pressure rise and the maximum rate of explosion pressure rise of a quiescent flammable gas/air/inert mixture in 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 pressures and 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. This European Standard does not apply to the design and testing of flameproof enclosures in conformity with EN 13463-6 (for non-electrical equipment) and EN 60079-1 (for electrical equipment).

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.

EN 13237, *Potentially explosive atmospheres — Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres*

3 Terms and definitions

For the purpose of this European Standard, the terms and definitions given in EN 13237 and the following apply.

3.1
explosion pressure
p_{ex}
highest pressure occurring in a closed vessel during the explosion of a specific mixture of flammable substances with air or air and inert gases determined under specified test conditions

NOTE p_{ex} is expressed as absolute pressure with gases and vapour and as overpressure with dusts.

3.2
maximum explosion pressure
p_{max}
maximum value of explosion pressure measured in the tests for explosion pressure when the content of the flammable substances in the mixture is varied

NOTE p_{max} is expressed as absolute pressure with gases and vapour and as overpressure with dusts.

3.3
rate of explosion pressure rise
$(dp/dt)_{\mathrm{ex}}$
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 substances with air or air and inert substances determined under specified test conditions

3.4

maximum rate of explosion pressure rise

$(dp/dt)_{\text{max}}$

maximum value of the explosion pressure rise per unit time measured in the tests when the content of the flammable substances in the mixture is varied

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 a test vessel. By means of a pressure measuring system the pressure-time curve that develops following the ignition of the test mixture is recorded.

From the pressure- time curve the highest rate of explosion pressure rise $(dp/dt)_{\text{ex}}$ is calculated, and the highest pressure p_{ex} is determined.

Repeat measurements are made with stepwise variations in the content of flammable gas in the mixture.

a) The maximum explosion pressure p_{max} is determined as the maximum observed value of $p_{ex.}$

b) The maximum rate of explosion pressure rise $(dp/dt)_{\text{max}}$ is determined as the maximum observed value of $(dp/dt)_{\text{ex}}$

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 EN 14460.

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.

4.2.3 Equipment for preparing the test mixture

The test mixture can be prepared by a partial pressure method or mixing together flows of the component substances. This can be done in the test vessel or outside.

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

a) a vacuum pump and a vacuum gauge;

b) pressure gauges or manometers;

c) 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:

d) flow meters (mass or volume flow meters);

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

f) an evaporator if liquid samples are used (see annex E 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 a maximum 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 induction spark and fusing wire. The test report shall state 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 insulation from the test vessel body.

A high voltage transformer, with a root mean square voltage of 13 kV to 16 kV (AC) 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.

NOTE 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 explosion pressure. 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 insulation 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) a pressure transducer;

    1) The pressure transducer(s) shall be fitted in the test vessel, with the head flush with the internal wall.

    2) The pressure transducer(s) shall be able to measure pressures up to 20 bar. Pressure transducers of lower range may be used if lower explosion pressures are expected.

b) an amplifier;

c) a data recording system.

    1) The data recording system shall have a resolution of at least 12 bit and either a sampling rate of 20 kHz, or a sampling rate of $500/t_{\text{ex}}$ samples per second.

    2) t_{ex} is the time from ignition to the maximum explosion pressure. (see Figure C.1 and Figure C.2).

d) The pressure measuring system shall have a bandwidth of at least 10 kHz

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

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

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

4.2.6 Temperature measuring device

Any suitable thermocouple with appropriate recording equipment may be used to record this value. Recording the temperature is necessary, because especially p_{ex} and p_{max} are temperature dependent.

4.2.7 Safety aspects

Ensure that all work is conducted within local and national regulations. Precautions shall be taken to safeguard the health of personnel conducting the tests against the different hazards that may occur during the test e.g.:

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

b) 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 a test;

c) 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;

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

e) adequate ventilation shall be provided to prevent the build up of an explosive atmosphere in the laboratory as a result

   1) of purging of the apparatus;

   2) exhaust from the vacuum pump;

   3) or leaks from the apparatus.

f) all electrical connections shall be adequately insulated to prevent electrocution or shock to personnel;

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

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

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

j) the handling of gas cylinders shall be carried out in such a manner that the risk of an explosion is minimised;

k) in the event of ignition system failure, the explosive mixture will still be present at the end of the test, purge and diltute to render non-flammable.

4.3 Preparation and preservation of test samples

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

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

b) 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.

c) Flammable gas: the flammable gas may be derived from:

1) a single substance or a mixture of substances,

2) 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 may 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 shall be taken into account when calculating the pressures of combustible substances 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 shall be evacuated or purged.

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

4.4.1.3 Preparation of the test mixture by mixing flows

The test mixture is prepared by thoroughly mixing metered flows of the gaseous components.

If liquid components are used, they shall be vaporised totally before mixing.

NOTE It is recommended that if possible the composition of the test mixture is also measured, to check the metering devices are operating correctly and that there are no leaks in the mixing system.

4.4.2 Determination of the explosion pressure p_{ex}, the maximum explosion pressure p_{max}, the rate of explosion pressure rise $(dp/dt)_{ex}$ and the maximum rate of explosion pressure rise $(dp/dt)_{max}$

4.4.2.1 Test procedure

The same sets of data are used for the determination of the explosion pressure and rate of explosion pressure rise, gathered simultaneously by the same procedure.

If the test mixture is not prepared in the test vessel, fill the vessel with the test mixture either by preliminary evacuation or by purging.

The test vessel and the feed lines shall be evacuated to a pressure of 5 mbar or less before filling. Purging shall be done in such a way that the test vessel atmosphere is totally replaced. This is achieved by purging with a volume that is at least ten times the vessel volume.

Once the test mixture has been introduced into the test vessel, the inlet and outlet valves shall be closed. The test mixture shall be left for a period of at least two minutes to ensure it is quiescent. The test mixture is then ignited and the pressure-time curve of the explosion recorded.

During a set of tests the temperature increase of the vessel (caused by the combustion after ignition) shall not be allowed to exceed 15 K (see 4.5.2)

After the test residual overpressure shall be released from the test vessel. Following this, the vessel shall be purged with air to remove the combustion products. The combustion products and purge gas shall be discharged safely.

The humidity of the gas mixture can influence the rate of pressure rise, so it is important to ensure that the test vessel and feed lines have been purged of all moisture before starting the next test.

If soot is formed during the test, the test vessel and the igniter shall be cleaned.

The whole test procedure shall be carried out five times for each composition of the test mixture.

- For determination of p_{ex} the number of determinations may be reduced to three, provided the scatter in the three tests is not greater than 0,5 bar.
- For the determination of $(dp/dt)_{ex}$ the number of determinations can be reduced to three, provided the relative standard deviation is not greater than 10 %.

4.4.2.2 Determination of the explosion pressure p_{ex}

The highest pressure on each of the pressure-time curves for a given composition measured by the procedure in 4.4.2.1 is determined by one of the following methods.

a) Graphical method

   From a plot of pressure versus time, which may be the analogue output from a recording instrument, the highest pressure shall be determined. The precision of the data used for the plot and the scale of the graph shall be sufficient to allow the pressures to be resolved to the nearest 0,1 bar.

b) Computational method

   A computer programme may be used to process the pressure-time data to determine the highest pressure. The precision of data used shall be sufficient to allow the pressures to be resolved to the nearest 0,1 bar.

The explosion pressure p_{ex} is the highest value of these determinations.

For fast reacting mixtures, the pressure time curves can show high frequency oscillations. These shall be discounted in determining p_{ex}.

4.4.2.3 Determination of $(dp/dt)_{ex}$

The highest $(dp/dt)_{ex}$ on each of the pressure-time curves at the given composition is determined by the following method.

The pressure-time plot from each test is differentiated to obtain the highest value of the slope (first derivative) for each test. In many cases it may be first necessary to smooth the raw pressure-time data, otherwise erroneous values of the slope may be calculated. Where smoothing techniques are required they shall conform to the requirements of Annex C.

The rate of explosion pressure rise $(dp/dt)_{ex}$ is the highest value of the slope derived from the tests.

4.4.2.4 Determination of the maximum explosion pressure p_{max} and maximum rate of explosion pressure rise $(dp/dt)_{max}$.

The maximum explosion pressure p_{max} and maximum rate of explosion pressure rise $(dp/dt)_{max}$ are both determined by varying stepwise the amount of flammable gas in a flammable gas/air mixture, until the respective maxima of p_{ex} and $(dp/dt)_{ex}$ are attained.

p_{max} and $(dp/dt)_{max}$ are both normally found for mixture compositions near the stoichiometric ratio, although they are not necessarily coincident. In order to determine the maximum explosion pressure or maximum rate of pressure rise with sufficient accuracy and with the minimum number of measurements, the following iterative procedure shall be used. Having determined one it may still be necessary to perform further measurements to determine the other.

Step 1

Choose from existing knowledge, calculation or estimation, the flammable gas content at which p_{max} and/or $(dp/dt)_{max}$. is expected to occur. This chosen value of flammable gas content is taken as the reference value. If the stoichiometric ratio for the reaction of the flammable gas with oxygen can be calculated, then 1,1 times the stoichiometric ratio may be used as the reference value. Otherwise estimate the reference value , for example by analogy to other flammable gases of similar composition or in the same homologous series. In the case of process samples of unknown composition, it is recommended that twice the value of the lower explosion limit is used as an estimate of the stoichiometric composition.

Step 2

Follow the procedure given in 4.4.2.1, 4.4.2.2 and 4.4.2.3 for the four mixtures with a flammable gas content of 0,8 times; 1,0 times; 1,2 times and 1,4 times the reference value. In cases where there is a high degree of confidence that p_{max} and/or $(dp/dt)_{max}$. occurs near the reference value, the number of mixtures may be reduced to three and the incremental value may be reduced to less than 0,2 times the reference value.

Step 3

Calculate the mean of the three or five sets of p_{ex} and/or $(dp/dt)_{ex}$ values obtained for each flammable gas content. Find the highest value of these means determined so far.

Step 3.1

If the highest value found in step 3 is at the highest or lowest value of flammable gas content used, then extend the range of flammable gas content used. Choose two additional values of flammable gas content, either at the lower or higher end of the range as appropriate, at incremental values of 0,2 times the reference value. Otherwise proceed to step 3.2.

Step 3.2

If the highest value found in step 3 lies within the range of flammable gas content used, choose two additional values of flammable gas content at the midpoints of the intervals to the left and right of the point giving the highest mean.

Step 3.3

If there is more than one highest mean value, each one shall be treated separately according to step 3.1 or 3.2.

Step 4

Follow the procedure given in 4.4.2.1, 4.4.2.2 and 4.4.2.3 for the new values of flammable gas content calculated according to steps 3.1 or 3.2.

Step 5

Repeat steps 3 to 4 until:

- For p_{max} the change in the measured values of the explosion pressures is less than the accuracy of the pressure measuring system (0,05 bar or better, see 4.2.5);
- or for $(dp/dt)_{\mathrm{max}}$. the change in mean value is less than 10 %

or for either measurement

- the flammable gas content increment is less than the accuracy of the equipment used for preparing the test mixture (± 10 % relative for a flammable gas content up to 2 % mol and ± 0,2 % absolute for a flammable gas content above 2 % mol, see 4.2.3).

Step 6

Take the highest measured value of the explosion pressure as the maximum explosion pressure p_{max}.

Take the highest measured value of the rate of explosion pressure rise as the maximum rate of explosion pressure rise $(dp/dt)_{\mathrm{max}}$.

4.5 Expression of results

4.5.1 Common aspects

In reporting results of these determinations, all the information specified in 4.6 shall be provided.

The flammable gas content shall be stated either as mole fraction, volume fraction or mass fraction. For more details, see Annex D. For the maximum deviation of the flammable gas content, the maximum value of ± 0,2 % absolute or the corresponding value calculated from the relative deviation of ± 10 % shall be stated (see 4.2.3). A smaller deviation can be stated if it can be shown that the mixture was prepared to a greater accuracy (either by the method used or from analysis of the mixture).

NOTE The specific conditions and the objective of the method described in this standard do not permit the results to be evaluated by conventional statistical methods. They are not applicable here as the conditions regarding the distributions of random deviations are not met and systematic deviations - caused by the influence of the conditions of measurement - cannot be separated from random deviations. It is for this reason that it is necessary to note in the test report (see 4.6).

4.5.2 Explosion pressure and maximum explosion pressure

In reporting results of these determinations, all the information specified in 4.6 shall be provided.

For explosion pressure p_{ex} the evaluation of the test is based on the highest pressure of 5 tests carried out with the actual test mixture. In order to take into account all uncertainties (pressure measuring, flammable gas content, calibration, procedure with limited number of tests) this value is rounded up to the nearest 0,1 bar. In addition, the flammable gas content in the actual test mixture shall be stated.

For maximum explosion pressure p_{max} the evaluation of the test is based on that test mixture which gives the highest explosion pressure of all. In order to take into account all uncertainties (pressure measuring, flammable gas content, calibration), the highest value is rounded up to the nearest 0,1 bar. In addition, the flammable gas content in the test mixture which gave this highest value and the value of the last flammable gas content increment shall be stated to indicate the accuracy of the determination.

NOTE 1 Many substances show for temperatures up to 200 °C and pressures up to 2 bar the following temperature and pressure dependence for p_{max} :

$$p_{max}(T,p) = \frac{p_{max}(T_1,p_1) \cdot T_1 \cdot p}{T \cdot p_1}$$

T:	temperature of the mixture before ignition	in K
T_1:	reference temperature	in K
p:	pressure of the mixture before ignition	in bar
p_1:	reference pressure	in bar
$p_{max}(T,p)$:	p_{max} for the mixture conditions T and p before ignition	in bar
$p_{max}(T_1,p_1)$:	p_{max} at reference temperature T_1 and reference pressure p_1	in bar

Similar dependences can be expected for p_{ex}, except for near limit mixtures.

NOTE 2 As the values are obtained for safety purposes, the highest values of pressure are used instead of the mean values.

The verification of the apparatus and procedure shall be carried out according to Annex A.

4.5.3 Rate of pressure rise and maximum rate of pressure rise

In reporting results of these determinations, all the information specified in 4.6 shall be provided.

The values for $(dp/dt)_{ex}$ and $(dp/dt)_{max}$ will depend on the volume and shape of the test vessel used for the determination. For example, $(dp/dt)_{max}$ decreases with increasing vessel volume. It is, therefore, the practice to quote a rate of explosion pressure rise normalised to a vessel volume of 1 m^3 (K_G), using the following equation:

$$K_G = (dp/dt)_{max} V^{1/3} \qquad (1)$$

where

V is the vessel volume.

The above equation is based on an idealised treatment of a gas explosion, referred to as the 'cubic law', which assumes K_G will be independent of vessel volume. However, it has been shown that this is not the case (1) and that K_G increases with vessel volume.

It is also implicit in deriving the above equation that $(dp/dt)_{max}$ is measured in a spherical vessel with central ignition. Thus for valid comparisons to be made between $(dp/dt)_{max}$ or K_G values for different flammable gases, the determinations shall be carried out using the same conditions in vessels of identical shape and volume.

For rate of explosion pressure rise $(dp/dt)_{ex}$, the evaluation of the test is based on the highest rate of pressure rise of 5 tests carried out with the actual test mixture. In order to take into account all uncertainties (pressure measurements, flammable gas content, calibration of the measuring equipment, apparatus verification, procedure with a limited number of tests and the smoothing procedure) this value is rounded up according to Table 1. In addition, the flammable gas content of the test mixture on which the determination was undertaken shall be stated in the test report.

For maximum rate of explosion pressure rise $(dp/dt)_{max}$, the evaluation of the test is based on that test mixture which gives the highest rate of pressure rise. In order to take into account all uncertainties (pressure measuring, flammable gas content, calibration, smoothing), the highest value is rounded up according to the Table 1. In addition, the flammable gas content of the test mixture which gave the highest value and the value of the last flammable gas content increment used shall be stated in the test report.

Table 1 — Rules for rounding up $(dp/dt)_{ex}$ and $(dp/dt)_{max}$ values

Range of $(dp/dt)_{ex}$ or $(dp/dt)_{max}$	in bar/s	< 10	10 to 100	100 to 1 000	> 1 000
Rounding up to the nearest	in bar/s	0,1	1	10	100

The main contributing factors to the overall uncertainty of the rate of explosion pressure rise $(dp/dt)_{ex}$ measurements at a given flammable gas content are the uncertainty of the pressure measurements, the uncertainty of the flammable gas content values and the smoothing procedure used. To give a rough measure of the scatter of the measurements the lowest and highest values of rate of pressure rise shall be reported. The additional contributing factor to the overall uncertainty of the maximum rate of explosion pressure rise $(dp/dt)_{max}$ is the increment used for the flammable gas content.

As the values are intended for use in safety applications the highest value of the rate of pressure rise shall be used for $(dp/dt)_{max}$ instead of the mean values.

If the smoothing procedure is carried out according to the criteria given in Annex C, it should not have a significant effect on the calculated value of $(dp/dt)_{ex}$.

Verification of the test apparatus shall be carried out according to the procedure given in Annex B.

4.6 Test report

The test report shall give the following information:

a) laboratory name operator and date;

b) reference to the applied standard

c) test conditions:

   1) ambient temperature and pressure of the test mixture before ignition;

d) sample identification:

   1) flammable gas composition, source of flammable gas and purity;

e) oxidiser identification:

   1) atmospheric or synthetic air;

   2) composition, purity and amount of added inert;

f) test vessel:

   1) vessel shape;

   2) vessel volume;

g) ignition system;

h) preparation of test mixture; method used (including inside or outside preparation) and accuracy;

i) what is to be determined (p_{max} , p_{ex} ; $(dp/dt)_{\mathrm{max}}$, $(dp/dt)_{\mathrm{ex}}$);

j) results:

   1) in the case of p_{ex} or $(dp/dt)_{\mathrm{ex}}$:

      i) final explosion pressure; or final rate of explosion pressure rise, respectively

      ii) flammable gas content and accuracy;

      iii) highest, lowest and average values;

   2) in the case of p_{max} or $(dp/dt)_{\mathrm{max}}$:

      i) maximum explosion pressure; or maximum rate of explosion pressure rise, respectively

      ii) flammable gas content and accuracy;

      iii) smallest combustible content increment;

k) any other important information including the smoothing procedure.

An example of a form that may be used for a test report is given in annex F.

Annex A
(normative)

Verification of maximum explosion pressure values

This verification procedure shall be used for a new apparatus as well as checking the performance of existing apparatus. Existing apparatus shall be checked every 12 months or whenever parts of the apparatus have been changed or renewed.

The verification shall be carried out according to the procedures given in 4.3 and 4.4 for the substances listed in Table A.1. For a new apparatus, the four substances listed in Table A.1 shall be used, but for an existing apparatus it is sufficient to use only one of them.

Verification shall be confirmed if the values obtained from these experiments for the maximum explosion pressures and the flammable gas contents for maximum explosion pressure are in the ranges given in Table A.1.

Table A.1 — Values[a] for verification of the apparatus

Flammable gas	**Flammable gas content for maximum explosion pressure** mol %	**Maximum explosion pressure** bar
Ammonia	23,0 ± 1,0	5,0 ± 1,0
Methane	10,5 ± 0,5	8,3 ± 0,3
Hydrogen	31,0 ± 1,0	7,9 ± 0,3
Methanol	15,0 ± 0,5	8,8 ± 0,2

[a] These values were obtained at 25 °C and 1 bar, for mixtures of flammable gas with air.

NOTE 1 The values given in Table A.1 show the spread of results obtained from the determinations undertaken by the laboratories, that participated in the development of the method. For reasons stated above in 4.5, the results of these determinations could not, however, be evaluated according to the rules for inter-laboratory tests.

NOTE 2 The values given in Table A.1 can be converted to other units by using the formula given in Annex D.

NOTE 3 Additional special sets of data, obtained with a verified apparatus, can be used to check the performance of an apparatus for specific ranges of explosion pressure or flammable gas content.

NOTE 4 If the verification is carried out at pressure and temperature conditions different to 1 bar and 25°C, it is important to correct the values of the maximum explosion pressure to these conditions, using the equation given in 4.5.2, note 1, before comparing the results with the values given in Table A.1.

Annex B
(normative)

Verification of maximum rate of pressure rise

This verification procedure shall be used for a new apparatus as well as checking the performance of existing apparatus. Existing apparatus shall be checked every 12 months or whenever parts of the apparatus have been changed or renewed. Measurements for the verification tests shall be carried out according to the procedures given in 4.3 to 4.4 with mixtures of air and one of the substances given in Table B.1, with a 99,5 % purity or better. The composition of the mixture shall lie within the range given in Table B.1. For a new apparatus, the three substances listed in Table B.1 shall be used, but for an existing apparatus it is sufficient to use only one of them. Using the values given in Table B.1, plots of rate of explosion pressure rise $(dp/dt)_{ex}$ as a function of the test vessel volume V are given in Figures B.1 to B.3. Verification will be confirmed if, for a given value of V between 0,005 m^3 and 2 m^3, the corresponding value of the rate of explosion pressure rise $(dp/dt)_{ex}$ determined from the verification tests, lies in the region between the two curves of the relevant plot.

Table B.1 — Values[a] for verification of the apparatus[b]

Substance	Test vessel volume							
	0,005 m^3 sphere		**0,014 m^3 sphere**		**0,020 m^3 sphere**		**2 m^3 sphere**	
	x[c] %	$(dp/dt)_{ex}$ bar/s	x[c] %	$(dp/dt)_{ex}$ bar/s	x[c] %	$(dp/dt)_{ex}$ bar/s	x[c] %	$(dp/dt)_{ex}$ bar/s
Hydrogen	35 ± 0,3	4 883 ± 47	35 ± 0,2	3 321 ± 102	35 ± 0,3	2 965 ± 202	35 ± 2	1 193 ± 86
Methane	10 ± 0,2	362 ± 11	10 ± 0,1	217 ± 15	10 ± 0,1	235 ± 7,4	10 ± 1	78 ± 2
Ammonia	23 ± 0,5	28,3 ± 4,5	23 ± 0,2	19,2 ± 3	23 ± 0,2	21,8 ± 1,4	23 ± 2	3 ± 0,5

NOTE 1 The values reflect the spread of results obtained by the laboratories which participated in the development of the method. For reasons stated in 4.5, the results of these determinations could not, however, be evaluated according to the rules for inter-laboratory tests.

NOTE 2 The values may be converted to other units by using the formula given in Annex D.

NOTE 3 Additional sets of data, obtained with an apparatus, whose verification has been confirmed, may be useful to check the performance of the apparatus in specific ranges of rate of explosion pressure rise or flammable gas content.

[a] These values were obtained at 25 °C and 1 bar, for mixtures of flammable gas with air.

[b] the $(dp/dt)_{ex}$ values are not rounded according to Table 1 in 4.5

[c] mole fraction of the flammable substance in the flammable substance/air mixture.

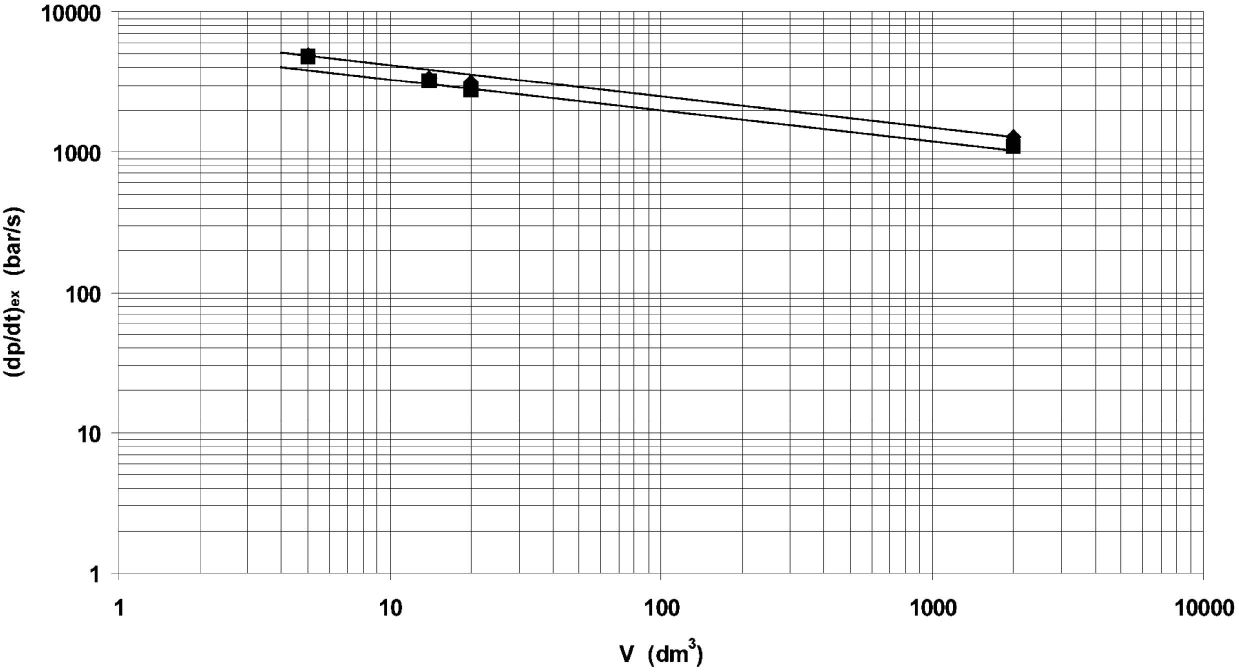


Figure B.1 — Plot of the rate of explosion pressure rise $(dp/dt)_{ex}$ as a function of the test vessel volume *V* for H_2-air mixtures ($x_{H2} \cong 35$ mol %)

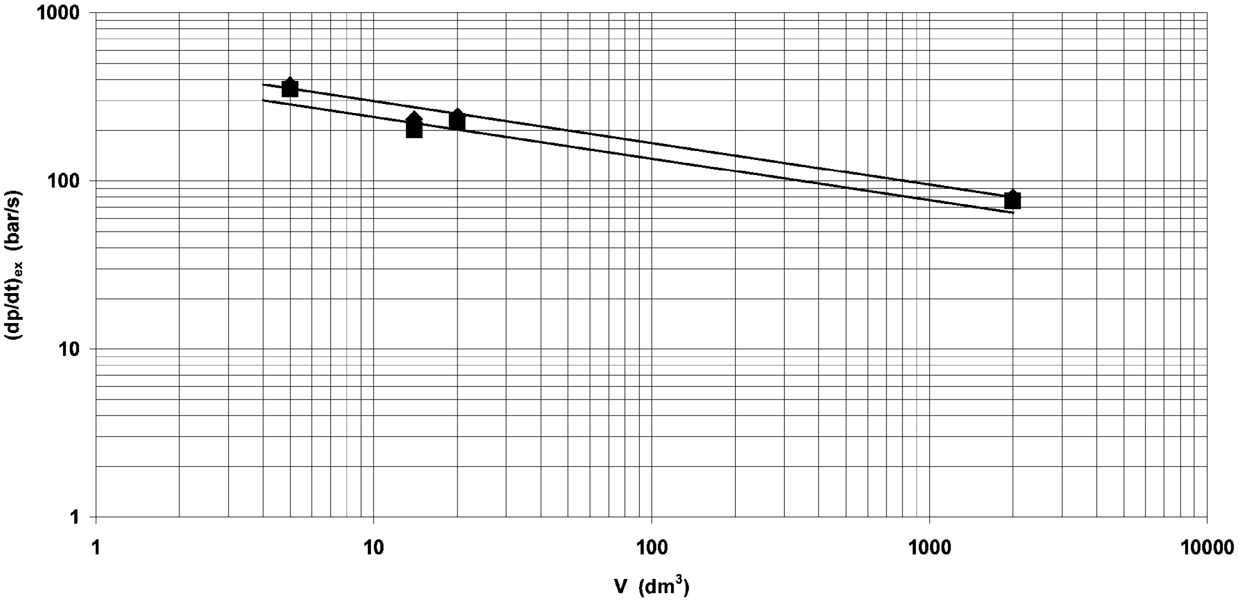


Figure B.2 — Plot of the rate of explosion pressure rise $(dp/dt)_{ex}$ as a function of the test vessel volume V for CH_4-air mixtures ($x_{CH4} \cong 10$ mol %)

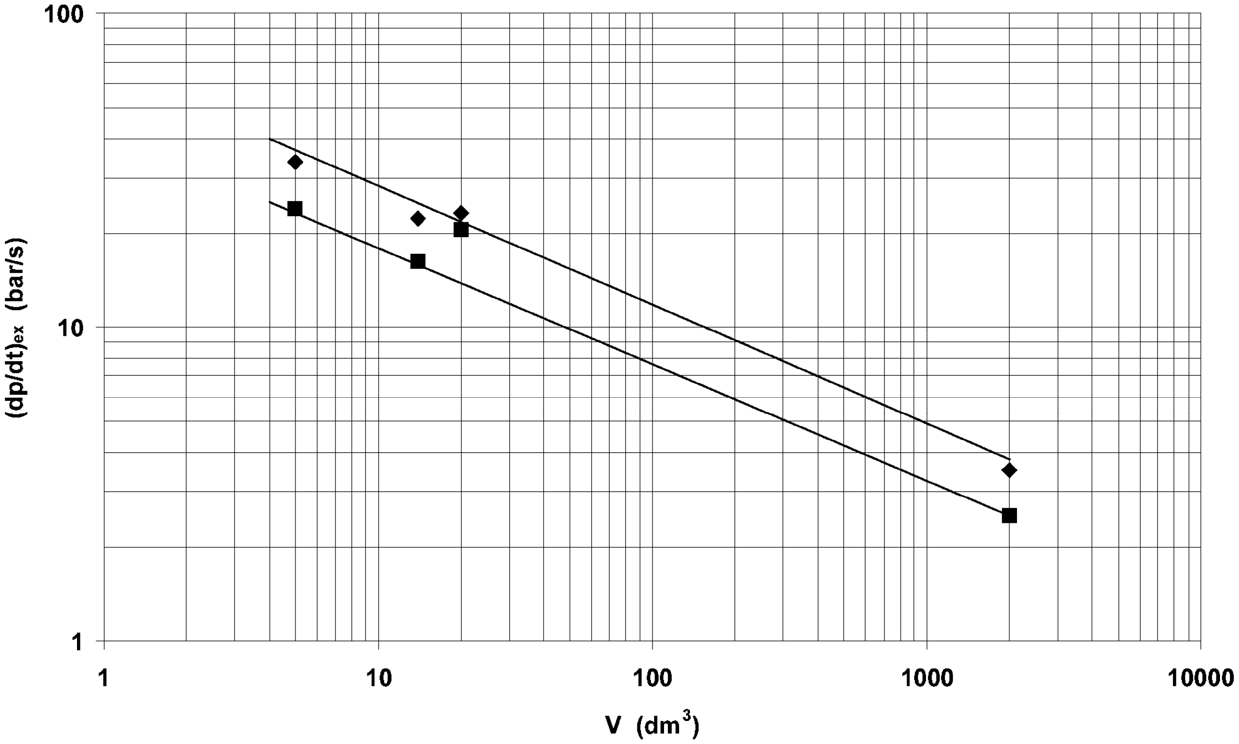


Figure B.3 — Plot of the rate of explosion pressure rise $(dp/dt)_{ex}$ as a function of the test vessel volume V for NH_3-air mixtures ($x_{NH3} \cong 23$ mol %)

Annex C
(normative)

Smoothing of pressure-time curves

Smoothing will certainly be required when the pressure-time curve exhibits oscillations around the time the highest rate of pressure rise occurs or if there is noise on the recorded curve. Figures C.1 and C.2 show examples of pressure-time curves where smoothing of the data would be required. The high pressure oscillations are a true pressure effect generated by the explosion in the test vessel and not due to resonance of the pressure gauge. The amplitude of the oscillations usually increases as the volume of the test vessel is increased.

Smoothing of the pressure-time curve can either be achieved by the use of filters in the data recording system, to remove specific ranges of frequency from the recorded signal, or by mathematical processing of the recorded data. A mathematical treatment is recommended as this will preserve the raw data for re-analysis if required. Use of filters in the recording system results in the data that has already been smoothed being recorded and the raw data is lost.

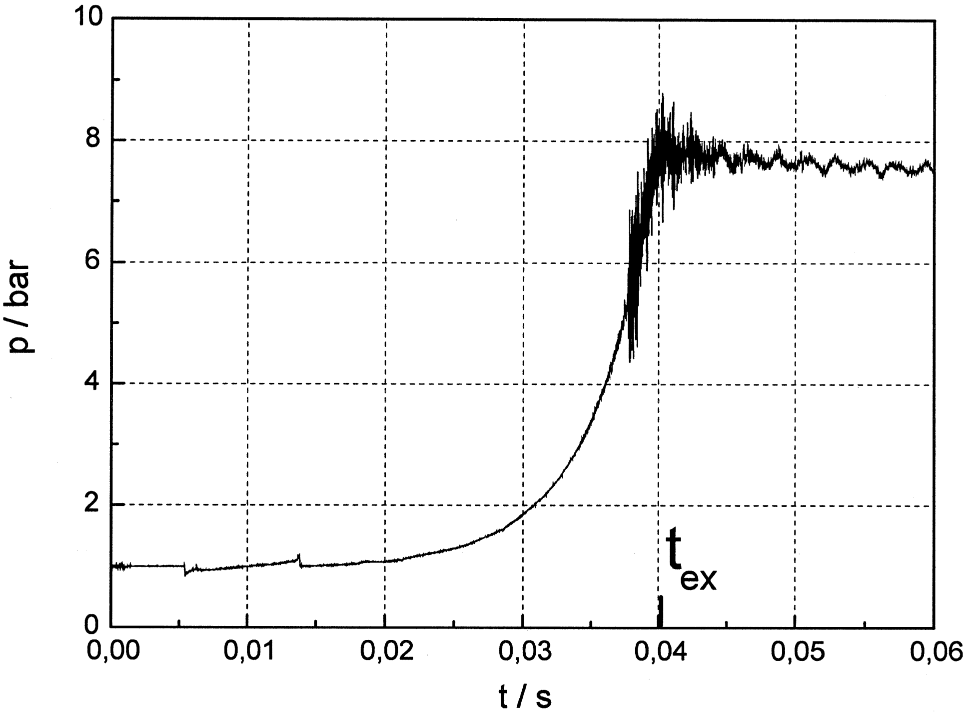
There are a number of mathematical methods than can be used for smoothing data, some examples are:

- averaging;
- linear regression;
- filtering (e.g. FFT);
- polynomial fitting.

Test houses may develop their own in-house mathematical treatments, but these days it is probably more convenient to use one of the many commercially available data analysis software packages that are supplied for use with data loggers.

Whatever the method used there is at least one parameter, for example the number of data points averaged over, or the degree of polynomial used, which shall be carefully selected to achieve the correct amount of smoothing. Figure C.3 illustrates schematically the effect of changing this parameter on the calculated rate of pressure rise. If the curve is not smoothed enough then the calculated rate of pressure rise will be too great and conversely if it is over smoothed the rate of pressure rise will be too small. There is a range of the parameter over which the plot shows a plateau in the rate of pressure rise. To obtain the correct value of the rate of pressure rise it is necessary to use a value of the parameter within this range. In some cases the smoothing may have to be applied a number of times to achieve the required degree of smoothing.

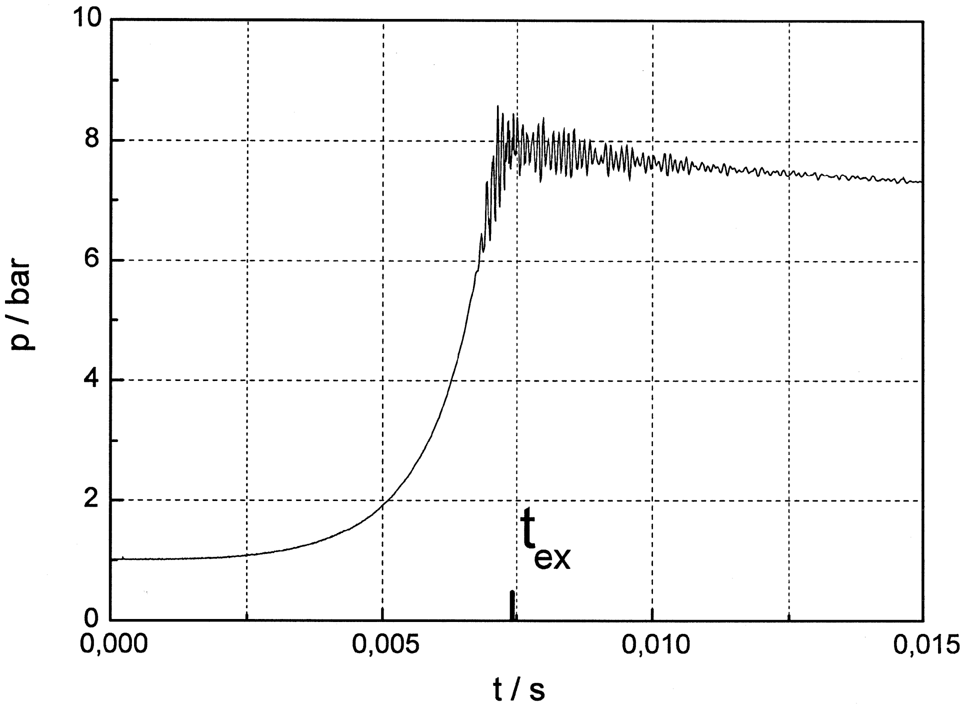
Test houses shall be able to demonstrate that if smoothing has been used it has been applied correctly, by being able to make comparisons between the raw and smoothed pressure-time curves.



Hydrogen-air mixture (35 % mol H_2) ignited in a 2 m^3 sphere.

t_{ex} is the time from ignition to maximum explosion pressure.

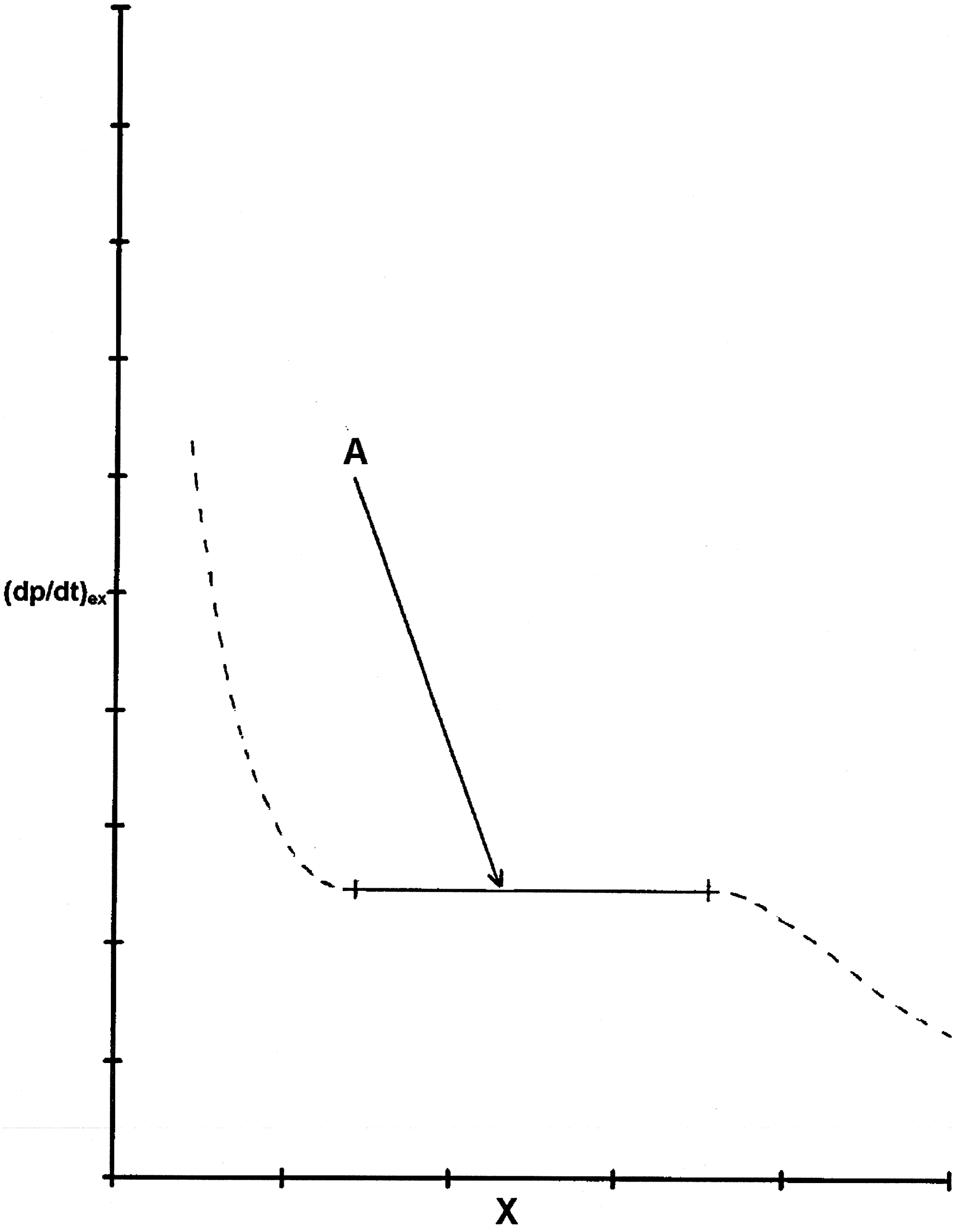
Figure C.1 — Example of a raw *p(t)* curve showing oscillations



Hydrogen-air mixture (35 % mol H_2) ignited in a 5 dm^3 sphere.

t_{ex} is the time from ignition to maximum explosion pressure.

Figure C.2 — Example of a raw *p(t)* curve showing oscillations



Key

A plateau (range of possible values of the smoothing parameter for suitable smoothing)

X smoothing parameter

Figure C.3 — Schematic diagram showing the variation of $(dp/dt)_{ex}$ as a function of a smoothing parameter

Annex D
(informative)

Conversion of the values for the flammable substance content

D.1 Abbreviations and symbols

D	density ratio
F	molar mass ratio (ratio of molar masses)
M	molar mass
m	mass
$\dot{m}$	mass flow
n	mole number (amount of substance)
Q	compressibility factor ratio
V	volume
V^{mol}	molar volume
$\dot{V}$	volume flow
w	mass fraction
x	mole fraction
Z	compressibility factor
φ	volume fraction
ρ	real density
at	atmospheric conditions, i.e. approximately 1 bar and approximately 20 °C
fl	liquid state of aggregation
(G)	gas, i.e. sample or air
N	standard conditions, i.e. at 1,013 bar and 0 °C
id	for (test mixtures as) ideal gas
(A)	air
mol	to characterise the molar volume
(S)	flammable substance

D.2 Substance characteristics of air

ρ_{at}	$1{,}2 \times 10^{3}$ g/m^{3}
$M(A)$	29,0 g/mol

D.3 Definitions[1]

Volume fraction in %

$$\varphi(S) = \frac{\dot{V}(S)}{\dot{V}(S) + \dot{V}(A)} \times 100 \qquad \text{(D.1)}$$

When contents are stated as volume fraction, the volume flows have to be related to the same pressure and to the same temperature and all components have to be gaseous under these conditions.

Mole fraction %

$$x(S) = \frac{n(S)}{n(S) + n(A)} \times 100 \qquad \text{(D.2)}$$

The mole fraction is independent of pressure and of temperature.

Mass fraction in %

$$w(S) = \frac{\dot{m}(S)}{\dot{m}(S) + \dot{m}(A)} \times 100 \qquad \text{(D.3)}$$

The mass fraction is independent of pressure and of temperature.

D.4 Preparation of the test mixture

According to 4.4.1, it is possible to prepare the test mixture in different ways:

a) By partial pressures;

In this case, moles are mixed.

b) Metering of air and gaseous samples using mass flow controllers: In this case mass flows are brought together under atmospheric conditions to form the test mixture. If the mass flow controllers are calibrated in volume flow in standard conditions $\dot{V}_{\mathrm{N}}\,(G)$, the mass flow shall be obtained by multiplying this volume flow by the density of the gas at standard conditions $\rho_{\mathrm{N}}(G)$ as follows:

$$\dot{m}(G) = \rho_{\mathrm{N}}(G) \times \dot{V}_{\mathrm{N}}(G) \qquad \text{(D.4)}$$

c) Metering of air with a mass flow controller and of liquid samples with a volumetric metering pump: For the mass flow of air the same as in case b is valid. The mass flow of the sample is obtained from the volume flow of liquid $\dot{V}_{fl}(S)$, which can be adjusted on the metering pump, and the density of the liquid $\rho_{\mathrm{fl}}(S)$ as follows:

$$\dot{m}(S) = \rho_{fl}(S) \times \dot{V}_{fl}(S) \qquad \text{(D.5)}$$

Using this method, the test mixture is produced at the increased temperature (temperature in the evaporator), necessary to produce the required amount of flammable substance in the test mixture. When mixing, both flows have to be at this temperature. The partial pressure of the test substance in the test

---

[1] The definitions used are in accordance with the German proposal for ISO/TC 158.

mixture cannot exceed the vapour pressure of the sample at this temperature. As the air and test substance thus are not at the same pressure when mixed, the conditions for the conversion into volume fractions are not fulfilled.

For comparison, the amount of flammable substance and the deviation can be converted as follows: The following substance characteristics are required for the conversion:

- the density ratio D of the densities of the gaseous sample $\rho(S)$ and of the air $\rho(A)$

$$D = \frac{\rho(S)}{\rho(A)} \tag{D.6}$$

- the molar mass ratio F of the molar masses of the sample $M(S)$ and of the air $M(A)$

$$F = \frac{M(S)}{M(A)} \tag{D.7}$$

- the compressibility factor ratio Q of the compressibility factors of the sample $Z(S)$ and of the air $Z(A)$

$$Q = \frac{Z(S)}{Z(A)} \tag{D.8}$$

Furthermore,

$$\frac{D \times Q}{F} = 1 \tag{D.9}$$

If the densities are not known but the real molar volumes for the gaseous sample $V^{mol}(S)$ and for the air $V^{mol}(A)$ are known, the following is valid:

$$D = F \times \frac{V^{mol}(A)}{V^{mol}(S)} \tag{D.10}$$

For the conversion, substance characteristics have to be used for the pressure and temperature conditions under which the flows of the components were brought together during the determination.

If the sample is a mixture or if an air/inert gas mixture is used as oxidizer in the place of air, the substance characteristics can be calculated from the well known formulae of physical chemistry or to be determined by measurements on the mixtures. If the substance characteristics are not known or cannot be calculated, a conversion of the values will not be possible.

Under the conditions stated above, the conversion formulae given in Table D.1 are valid for the quantities defined above:

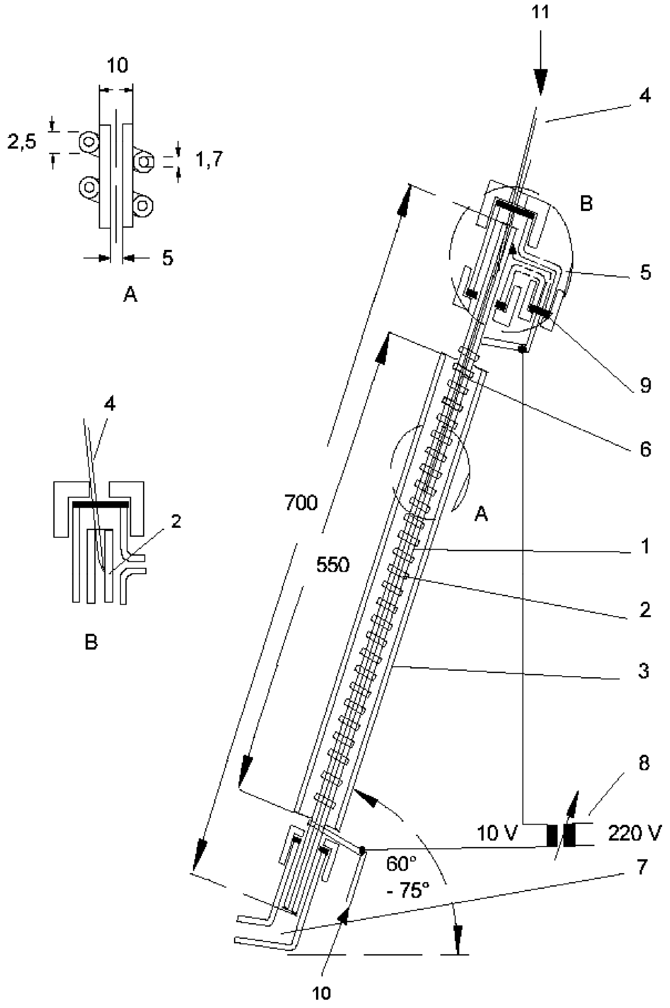
Table D.1 — Formulas for the conversion

	Mixed as		
To be calculated:	Volume fraction of flammable substance in the test mixture $\varphi(\mathrm{S})$ %	Mass fraction of flammable substance in the test mixture $w(\mathrm{S})$ %	Mole fraction of flammable substance in the test mixture $x(\mathrm{S})$ %
Volume fraction of flammable substance in the test mixture $\varphi(\mathrm{S})$ in %		$\varphi(\mathrm{S}) = \frac{\mathrm{w(S)/D} \cdot 100}{\mathrm{w(S)/D} + [100 - \mathrm{w(S)}]}$	$\varphi(\mathrm{S}) = \frac{\mathrm{Q} \cdot \varphi(\mathrm{S}) \cdot 100}{\mathrm{Q} \cdot \varphi(\mathrm{S}) + [100 - \varphi(\mathrm{S})]}$
Mass fraction of flammable substance in the test mixture $w(\mathrm{S})$ in %	$\mathrm{w(S)} = \frac{\varphi(\mathrm{S})/\mathrm{D} \cdot 100}{\varphi(\mathrm{S})/\mathrm{D} + [100 - \varphi(\mathrm{S})]}$		$\mathrm{w(S)} = \frac{\mathrm{x(S)} \cdot \mathrm{F} \cdot 100}{\mathrm{x(S)} \cdot \mathrm{F} + [100 - \mathrm{x(S)}]}$
Mole fraction of flammable substance in the test mixture $x(\mathrm{S})$ in %	$\mathrm{x(S)} = \frac{\varphi(\mathrm{S}) \cdot 100}{\varphi(\mathrm{S}) + [100 - \varphi(\mathrm{S})] \cdot \mathrm{Q}}$	$\mathrm{x(S)} = \frac{\mathrm{w(S)/Q} \cdot 100}{\mathrm{w(S)/Q} + [100 - \mathrm{w(S)}]}$	

Annex E
(informative)

Example of an evaporator equipment for liquid flammable substances

Dimensions in millimetres



Key

1	glass evaporator tube
2	helical steel tube (tight fit when heated)
3	heat shield (glass tube)
4	needle of the metering device for the liquid flammable substance
5	glass sealing cap with septum
6	thermocouple
7	test mixture outlet
8	low-voltage supply
9	gasket
10	air
11	liquid flammable substance

Figure E.1 — Evaporator equipment for producing test mixtures from liquid flammable substances

The glass evaporator tube (Figure E.1 (1)) with the tightly fitted helical steel tube (Figure E.1 (2)) is located in a glass tube heat shield (Figure E.1 (3)) of sufficient length. The evaporator tube is heated by applying a low-voltage to the helical tube. The temperature in the evaporator tube is controlled and measured by a thermocouple positioned inside the tube (Figure E.1 (6)). The air is preheated as it flows up through the hot helical steel tube. Thus the preheated air enters the top of the evaporator tube, together with the liquid from the needle of the metering device (Figure E.1 (4)). The needle is to be arranged in such a way that the liquid flowing from the tip of the needle immediately comes into contact with the wall of the evaporator tube. Formation of liquid drops as the sample flows from the needle tip has to be avoided. To achieve the most efficient evaporation, the evaporator is inclined at an angle of 60° to 75° to the horizontal and the temperature maintained so that all the liquid evaporates in the upper half of the tube.

Annex F
(informative)

Example for test report form[2]

Test Report

Laboratory name: ....

Determination of explosion pressure / maximum explosion pressure and rate of explosion pressure rise/maximum rate of explosion pressure rise according to EN ______

Test conditions

Temperature of the test mixture before ignition	....°C
Pressure of the test mixture before ignition	....bar

Test sample

Flammable substance	Composition or source .... Purity (mol%) ....
Air	Atmospheric Synthetic
Added Inert	Composition: .... Purity (mol%):..

Test Apparatus

Shape	Spherical Cylindrical
Volume	.... m^3
Ignition	Induction Spark Fusing Wire Other: (to be described precisely) ....

---

2) Can be copied for reporting the results of the determinations.

Preparation of Test Mixture	Partial pressure Mixing flows		inside the vessel outside the vessel	
	Accuracy: within	%	relative	absolute

☐ **Determination of the explosion pressure**

Content of flammable substance	....	% volume % mass % mol
Accuracy	....	absolute
Lowest explosion pressure in 5 (resp. 3) tests	....	bar
Highest explosion pressure in 5 (resp. 3) tests	....	bar
Mean value of explosion pressure in 5 (resp. 3) tests	....	bar
Explosion pressure	....	bar

☐ **Determination of the maximum explosion pressure**

Content of flammable substance	....	% volume % mass % mol
Accuracy	....	absolute
Smallest flammable substance content increment	....	% volume % mass % mol
Maximum explosion pressure	....	bar

☐ **Determination of the rate of explosion pressure rise**

Content of Flammable Substance	....	☐ % volume ☐ % mass ☐ % mol
Accuracy	....	absolute
lowest rate of explosion pressure rise in 5 (respectively 3) tests	....	bar
Highest rate of explosion pressure rise in 5 (respectively 3) tests	....	bar

Mean value of rate of explosion pressure rise in 5 (respectively 3) tests	.... bar
rate of explosion pressure rise	.... bar
Smoothing method	

☐ **Determination of the maximum rate of explosion pressure rise**

Content of flammable substance	☐ % volume .... ☐ % mass ☐ % mol
Accuracy	.... absolute
Smallest flammable substance content increment	☐ % volume .... ☐ % mass ☐ % mol
Maximum rate of explosion pressure rise	.... bar
Smoothing method	

Comments:

....

....

....

Signature: Date:

Annex G
(informative)

Significant technical changes between this European Standard and the previous editions

This European Standard supersedes EN 13673-1:2003 and EN 13673-2:2005

Table G.1 — The significant changes with respect to EN 13673-1:2003 and EN 13673-2:2005

		Type		
Significant changes	Clause	Minor and editorial changes	Extension	Major technical changes
Editorial exercise to combine EN 13673-1:2003 and EN 13673-2:2005 into a single standard with no technical changes	All	X		

Annex ZA
(informative)

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

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 of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

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 given in Table ZA.1 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.

Table ZA.1 — Correspondence between this European Standard and Directive 94/9/EC

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 94/9/EC	Qualifying remarks/Notes
4.4 to 4.6	Annex II, 1.2.9	Explosion resistant enclosures
4.4 to 4.6	Annex II, 3.1.1 to 3.1.7	Protective systems
4.6	Annex II, 1.0.6a	
4.6	Annex II, 1.0.6c	

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

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

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 2006/42/EC of 17 May 2006 on the approximation of the laws of the Member States relating to machinery.

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 given in Table ZB.1 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.

Table ZB.1 — Correspondence between this European Standard and Directive 2006/42/EC

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 2006/42/EC	Qualifying remarks/Notes
4.2	Annex I, 1.5.7	

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

Bibliography

[1] EN 14460, *Explosion resistant equipment*

[2] EN 13463-3, *Non-electrical equipment for use in potentially explosive atmospheres – Part 3: Protection by flame proof enclosure "d"*

[3] EN 60079-1, *Electrical apparatus for potentially explosive atmospheres — Part 1: Flameproof enclosure "d" (IEC 60079-1:2003)*

[4] *National Fire Protection Association 68 "Standard on Explosion Protection by Deflagration Venting" (2007 Edition*

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