International Standard ISO 6184/2

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Explosion protection systems — Part 2: Determination of explosion indices of combustible gases in air

Systèmes de protection contre les explosions — Partie 2: Détermination des indices d'explosion des gaz combustibles dans l'air

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6184/2 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Explosion protection systems — Part 2: Determination of explosion indices of combustible gases in air

0 Introduction

0.1 The assessment of measures required to provide protection against explosion hazards involving combustible gas/air mixtures requires prior determination of the potential explosion severity of such mixtures, by the measurement of explosion indices. Conversely, the measurement of the effectiveness and performance of explosion protection systems requires that they should be tested against explosions of known severity.

The severity of a combustible gas explosion is a function of the following:

a) the chemical properties of the combustible gas;

b) the concentration of the combustible gas in the gas/air mixture;

c) the homogeneity and turbulence of the combustible gas/air mixture;

d) the type, energy, and location of the ignition source;

e) the geometry of the container;

f) the temperature, and pressure of the combustible gas/air mixture.

0.2 This part of ISO 6184 is one of a series dealing with explosion protection systems. The other parts are as follows:

Part 1: Determination of explosion indices of combustible dusts in air.

Part 3: Determination of explosion indices of fuel/air mixtures other than dust/air and gas/air mixtures.

Part 4: Determination of efficacy of explosion suppression systems.

0.3 The interpretation of explosion indices determined by the method specified in this part of ISO 6184 and their relation to the development of explosions in commonly encountered explosion hazards should be recognized. In particular, the degree of turbulence can influence the hazard significantly. In practice, the link between a given degree of turbulence and a specific type of hazard is the responsibility of specialists in the fields of explosions and explosion protection.

Two extremes of turbulence commonly encountered in industrial plants are:

a) quiescent conditions prevailing in storage vessels;

b) high turbulence conditions prevailing in the region of an extraction fan.

It should be realized that turbulence can arise in two ways:

a) turbulence intrinsic to the plant, under normal operating conditions, as a consequence of perturbations to the air-flow;

b) turbulence induced by obstructions within an installation on a gas which expands as the result of an explosion.

1 Scope

This part of ISO 6184 specifies a method for the determination of the explosion indices of combustible gases with air in an enclosed space. It gives the criteria by which results obtained using other test procedures can be correlated to yield explosion indices as determined by the method specified in this part of ISO 6184.

2 Field of application

This part of ISO 6184 is applicable only to the determination of explosion indices pertaining to the development of contained gas/air explosions after ignition of reactants. It does not apply to indices pertaining to the conditions necessary to cause ignition of the reactants. If the specified experimental procedure for the determination of explosion indices does not result in ignition of the gas/air mixture, it should not be concluded that the gas in question cannot explode. The interpretation of such cases should be left to specialists in the field of explosions and explosion protection.

3 Definitions

For the purpose of this part of ISO 6184 the following definitions apply.

3.1 explosion: Propagation of a flame in a pre-mixture of combustible gases, suspended dust(s), combustible vapour(s), mist(s), or mixtures thereof, in a gaseous oxidant such as air, in a closed, or substantially closed, vessel.

3.2 explosion index: Numerical term, determined in accordance with the test methods specified in this part of ISO 6184, which characterizes the contained explosion of a specified concentration of reactants in a vessel having a volume of 1 m^3.

NOTE — Figure 1 shows the pressure/time curve, expressed in bars[1)] and seconds respectively, of a typical explosion.

3.2.1 explosion index p_m: Maximum overpressure relative to the pressure in the vessel at the time of ignition attained during an explosion.

3.2.2 explosion index p_{max}: Maximum value of the explosion index p_m determined by tests over a wide range of reactant concentrations.

3.2.3 explosion index K: Constant defining the maximum rate of pressure rise with time $(dp/dt)_m$ of an explosion in a volume V, according to the equation

$$K = \left(\frac{dp}{dt}\right)_m \times V^{1/3}$$

NOTE — Under certain circumstances, this equation is not valid for vessels with a length to diameter ratio greater than 2 : 1 or with a volume of less than 1 m^3.

3.2.4 explosion index K_{max}: Maximum value of the explosion index K determined by tests over a wide range of reactant concentrations. The violence of an explosion is evaluated from the value of K_{max}.

3.3 turbulence index: Numerical term which characterizes the degree of turbulence in the experimental conditions under which the explosion indices are determined.

3.3.1 turbulence index t_v (ignition delay): Experimental parameter defined as the time interval between the initiation of a gas/air injection procedure in an experimental apparatus, and the activation of the ignition source. It characterizes the degree of turbulence prevailing at the moment of ignition.

3.3.2 turbulence index T_u: Ratio of the explosion index $K_{max, turbulent}$ determined as specified in this part of ISO 6184 to the explosion index $K_{max, quiescent}$ of the quiescent reactants. It is given by the equation

$$T_u = \frac{K_{max, turbulent}}{K_{max, quiescent}}$$

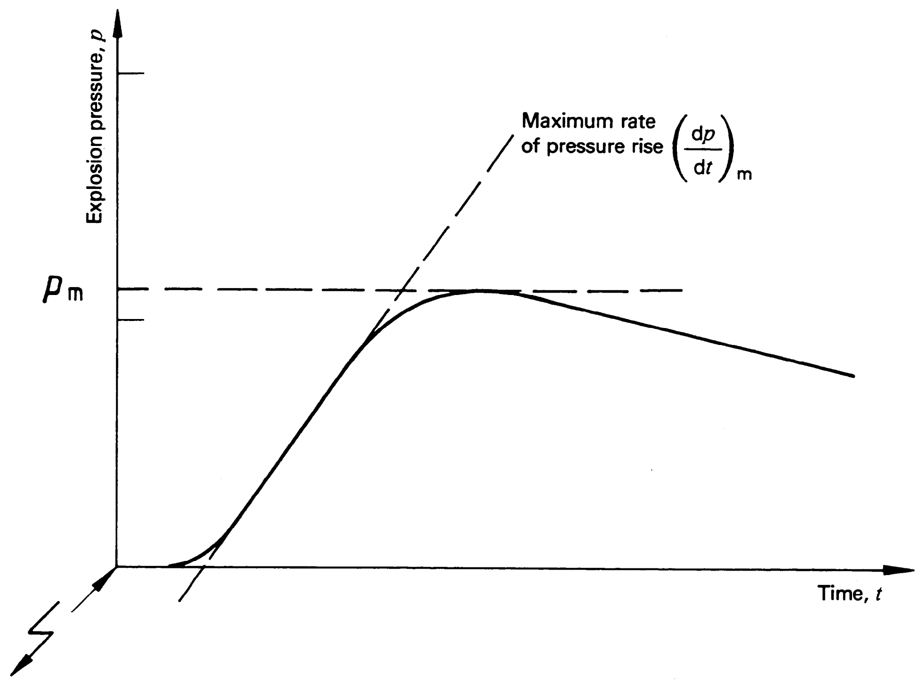

Figure 1

1) 1 bar = 10^5 Pa

4 Test method

4.1 General

The experimental apparatus described in this part of ISO 6184 is chosen as an example, and is suitable for the evaluation of explosion indices of combustible gases in air.

4.2 Apparatus

The apparatus consists essentially of a cylindrical explosion chamber with a volume of 1 m^3 and an aspect ratio nominally of 1 : 1, as shown in figure 2.

A container of approximately 5 l capacity is attached to the explosion chamber and is capable of being pressurized with air to 20 bar. This container is fitted with a 19 mm (3/4 in) quick-opening valve which allows injection of the contents of the container within 10 ms of opening the valve. The container is connected to the explosion chamber by means of a 19 mm (3/4 in) internal diameter tube which is formed into a perforated (4 to 6 mm hole diameter) semicircular spray pipe. The number of holes in the pipe shall be chosen such that their total cross-sectional area is approximately 300 mm^2.

Combustible gas/air mixtures, quiescent or turbulent, shall be ignited with an electric spark with an ignition energy greater than the minimun ignition energy for the material being tested.

For example, a suitable ignition source is a series of induction sparks sustained for 0,5 s.

NOTE — A suitable ignition source is produced by using a high voltage transformer (approximately 300 VA) with an output of 15 kV (effective value).

The spark gap should normally be 3 to 5 mm and shall be located in the geometric centre of the test apparatus.

The apparatus is arranged so that the ignition delay (turbulence index t_v) can be varied if necessary from test to test.

A pressure transducer is fitted to measure explosion chamber pressure, this being linked to a recorder.

NOTE — If a very high ignition energy is chosen, it is possible that the results will deviate from those obtained using a low energy ignition source, such as described above.

4.3 Procedure

4.3.1 Quiescent gas explosion test

Prepare the gas/air mixture in the 1 m^3 chamber by, for example, the method of partial pressures, the resultant mixture being at atmospheric pressure. It is important that the correctness and the homogeneity of the required gas/air mixture is verified. Ensure that the mixture is allowed to become quiescent. Start the pressure recorder and then activate the ignition source. Upon completion of each test, purge the explosion chamber with air.

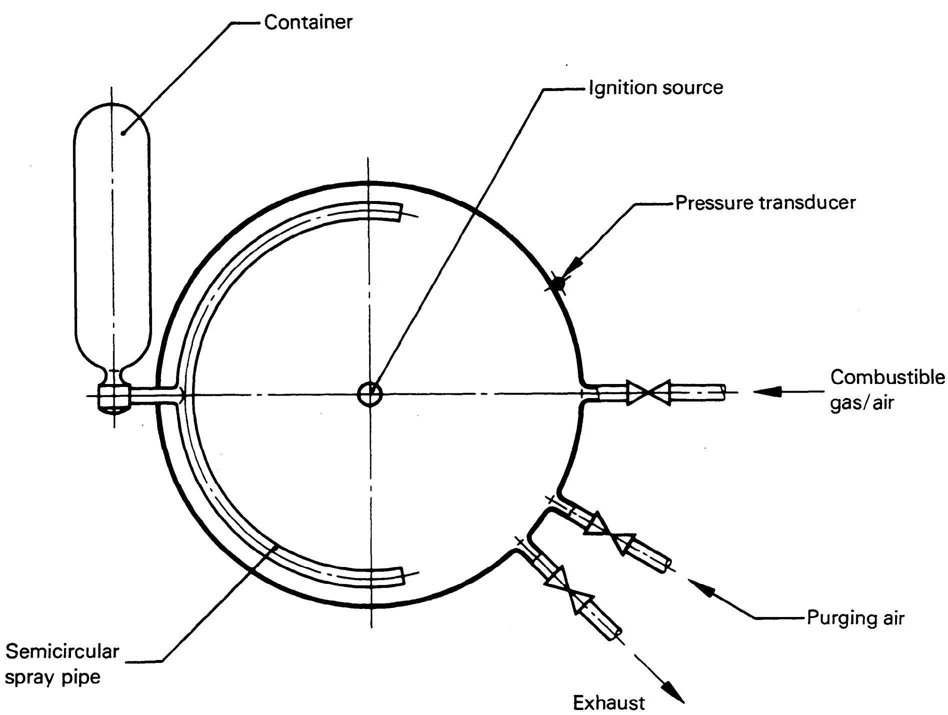

Figure 2

Repeat this procedure over a wide range of gas concentrations to obtain curves of p_m, in bars, and K, in bar metres per second, versus gas concentration, as percentages by volume [% (V/V)] to determine p_{max} and K_{max} respectively (see figure 3).

It should be noted that in certain cases combustion instabilities can occur as a result of geometric and ignition factors. These instabilities result in pressure/time curves which are not the symmetrical s-shape shown in figure 1. In such cases, interpretation of results should be left to specialists in the field of explosions and explosion protection.

4.3.2 Turbulent gas explosion tests

Prepare the gas/air mixture in the 1 m^3 explosion chamber in accordance with the method described in 4.3.1. Pressurize the 5 l container with air to 20 bar. Start the pressure recorder and then activate the sample container valve followed by the ignition source.

Ignition of the turbulent gas/air mixture at a chosen ignition delay, turbulence index t_v after the injection of the compressed air charge results in a turbulent gas explosion (see figure 4).

NOTE — The influence of the compressed air charge on the final explosive gas concentration should be taken into account. Upon completion of each test, purge the explosion chamber with air.

Repeat the procedure over a wide range of gas concentrations (see figure 3) to obtain curves of p_m and K to obtain p_{max} and K_{max} respectively.

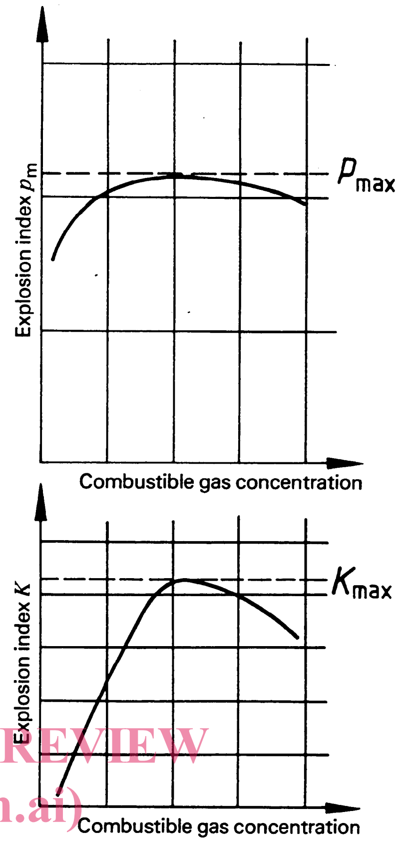

Figure 3

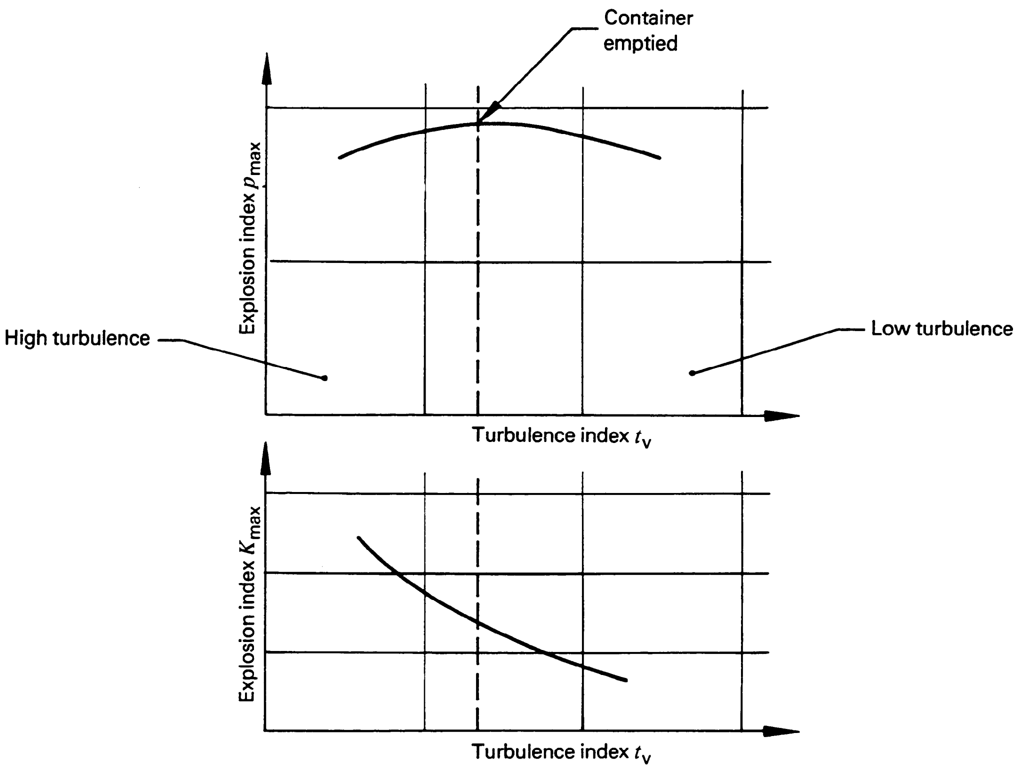

Figure 4

4.4 Alternative test methods

The explosion indices of combustible gas/air mixtures can be determined using alternative test equipment and/or test procedures providing that it has been proven that such methodology gives results commensurate with results obtained using the 1 m^3 apparatus for a large number of gases (see 4.3.1).

5 Interpretation of test results

The test methods described in clause 4 allow the explosion indices p_{max} and K_{max} of quiescent and turbulent gas/air mixtures to be determined. It can be stated that, in general, the accuracy of a p_{max} determination is ± 4 %. The accuracy of a K_{max} determination is dependent upon the conditions of turbulence of the mixture at the time of ignition.

6 Test report

The test report shall include the following information:

a) type of combustible gas;

b) conditions of turbulence (turbulence index) or quiescence;

c) combustible gas concentration corresponding to the p_{max} and K_{max} measurements;

d) explosion index p_{max}, in bars;

e) explosion index K_{max}, in bar metres per second;

f) any deviations from the test procedure specified in clause 4; such deviations are permissible, provided they are reported exactly;

g) date of test.

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