International Standard ISO 6184/3

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Explosion protection systems — Part 3: Determination of explosion indices of fuel/air mixtures other than dust/air and gas/air mixtures

Systèmes de protection contre les explosions — Partie 3: Détermination des indices d'explosion des mélanges de combustibles et d'air autres que les mélanges air/poussière et air/gaz

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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 6184/3 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting.*

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Explosion protection systems — Part 3: Determination of explosion indices of fuel/air mixtures other than dust/air and gas/air mixtures

0 Introduction

0.1 The assessment of measures required to provide protection against explosion hazards involving fuel/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 fuel/air explosion is a function of the following:

a) the physical and chemical properties of the fuel;

b) the concentration of the fuel in the fuel/air mixture;

c) the homogeneity and turbulence of the fuel/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 fuel/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 2: Determination of explosion indices of combustible gases in air.

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 turbulence 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 fuels in air (other than dust/air and gas/air mixtures) in an enclosed space. Fuel/air mixtures may be, for example, gas/air/dust mixtures and vaporized liquid/air mixtures. 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 fuel/air explosions after ignition of the reactants. It does not apply to indices pertaining to the conditions necessary to cause ignition of the reactants.

NOTE — Dust and gas/air mixtures, both at concentrations below the explosive range, can form explosive mixtures when combined. Dust which cannot be caused to explode even with a high energy ignition source may become explosive if a flammable gas or vapour is added.

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 fuel dispersion 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

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

NOTE — For fuel/air mixtures, $K_{max,\ quiescent}$ is a theoretically derived parameter.

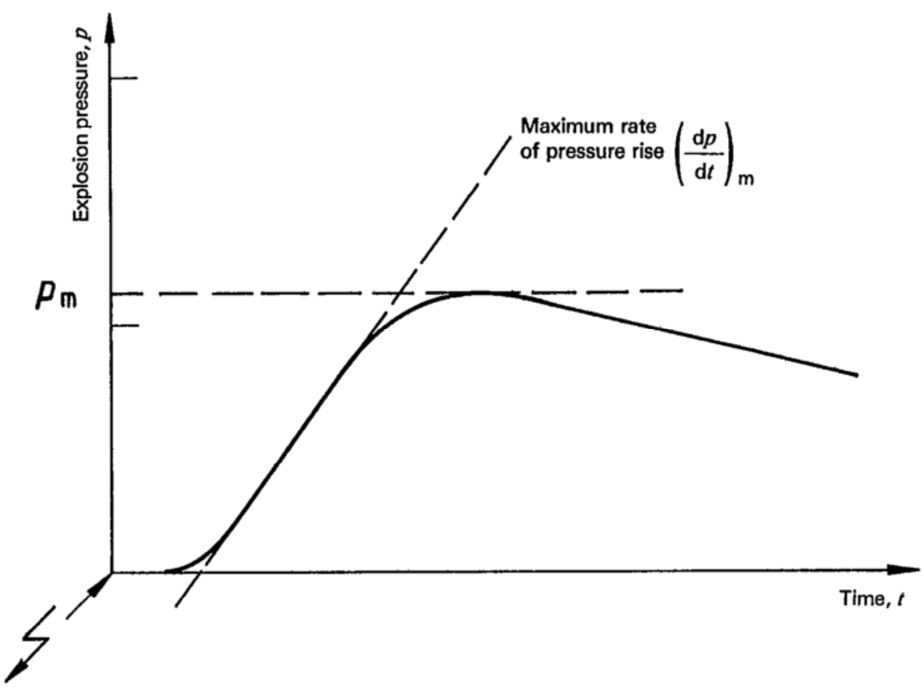

Figure 1

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 fuels mixed with air. If the fuel is a combustible gas or a combustible dust, the test procedures described in parts 1 and 2 respectively of this International Standard should be used. This part of ISO 6184 specifies the test procedure for the cases where the fuel is a hybrid (combustible gas plus dust) mixture and gives recommendations for the procedure for a combustible mist (fine droplets of combustible liquid) in air.

NOTES

1 When the gaseous oxidant is not air, but, for example, a nitrogen/oxygen mixture of different composition, the test procedures described in this part of ISO 6184 can be adapted by reading "oxidant" instead of "air".

2 When the initial pressure or temperature of the fuel/air mixture is not ambient, a test procedure similar to the procedures described in this part of ISO 6184 can be used.

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.

The ignition source comprises two pyrotechnic igniters with a total energy of 10 kJ and set to ignite after a fixed ignition delay, turbulence index t_v = 0,6 s. The total mass of the ignition source is 2,4 g and consists of 40 % zirconium metal, 30 % barium nitrate and 30 % barium peroxide. It is ignited by an electric fuse head. The igniter is located at the geometric centre of the explosion chamber. A pressure transducer is fitted to measure explosion chamber pressure, this being linked to a recorder.

4.3 Procedure

4.3.1 Hybrid mixture test

Prepare the gas/air mixture in the 1 m^3 chamber by, for example, using the method of partial pressures. It is important to ensure that the correctness and the homogeneity of the required gas/air mixture is verified.

Place the dust sample, the mass of which shall be that required to obtain the appropriate concentration, in the 5 l container and pressurize it with air to 20 bar. Start the pressure recorder and

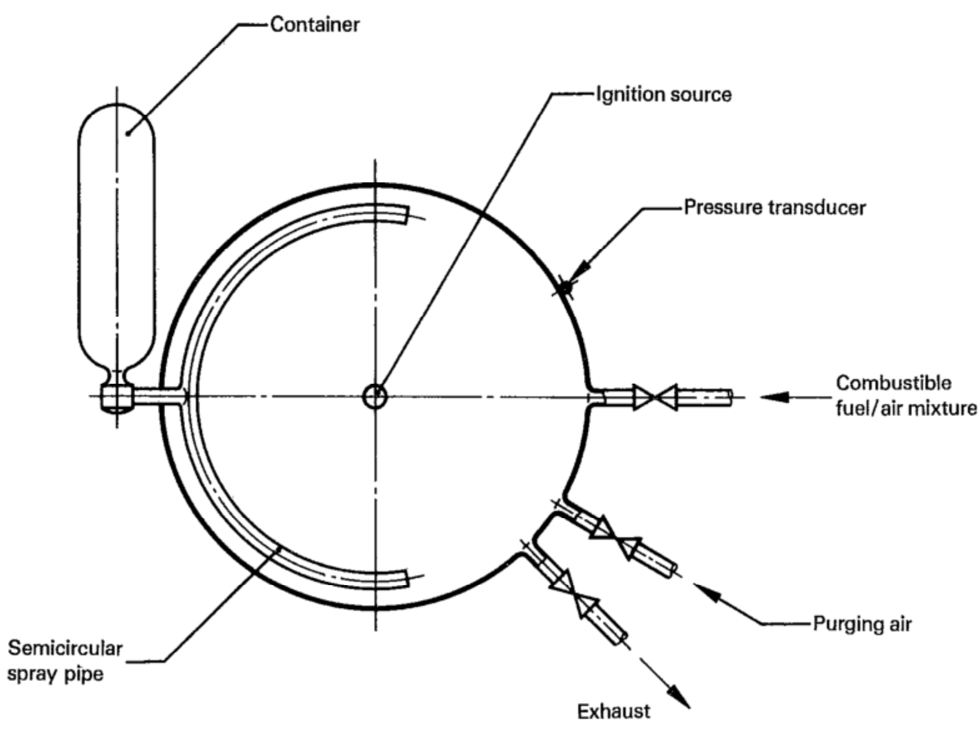

Figure 2

then activate the sample container valve followed by the igniter.

NOTE — Letting the compressed dust/air charge into the explosion chamber induces turbulence in the gas/air mixture. The influence of the compressed dust/air charge on the final explosive reactant concentration should be taken into account.

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

NOTE — The ignition delay turbulence index t_v chosen for these tests is the time interval needed to disperse all the dust in the explosion chamber. t_v corresponds to a specific level of turbulence T_u and hence has an influence on the measured K_{max} values. Since some turbulence always exists in a dust suspension, T_u is necessarily greater than 1.

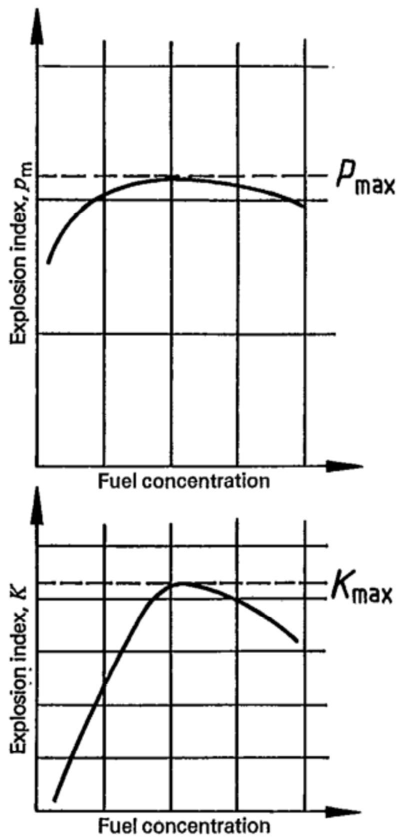

Figure 3

4.3.2 Mist/air mixture tests

Since, contrary to dusts, the particle sizes of the mist can vary widely depending on the situation in the plant, there is no standardized means of establishing the mist/air mixture.

It is therefore necessary to determine before the tests what droplet sizes will occur in the plant, and to select a test device that will create the right size of droplets and the right level of turbulence. After the mist/air mixture has been established, ignition of the mixture is effected in the geometric centre of the explosion chamber, using the ignition source mentioned in 4.3.1.

4.3.3 Determination of explosion indices

For the determination of the explosion indices p_{max} and K_{max} of fuel/air mixtures, tests should be carried out over a wide range of reactant concentration (see figure 3).

4.4 Alternative test methods

The explosion indices of fuel/air mixtures can be determined using alternative test equipment and/or test procedures providing that such methods give results commensurate with results obtained using the 1 m^3 apparatus for a large number of fuels.

5 Interpretation of test results

The test methods described in clause 4 allow the explosion indices p_{max} and K_{max} of fuel/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 on 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 fuels(s);

b) particle size distribution;

c) conditions of turbulence (turbulence index);

d) p_{max}, in bars;

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

f) fuel concentration corresponding to the p_{max} and K_{max} measurements;

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

h) in the case of mist/air mixtures, details of the mist generating device;

j) date of test.