International Standard

ISO 6184/1

Explosion protection systems — Part 1 : Determination of explosion indices of combustible dusts in air

Systèmes de protection contre les explosions — Partie 1: Détermination des indices d'explosion des poussières combustibles dans l'air

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Descriptors : explosion proofing, dust, tests, explosion index.

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 6184/1 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.

Explosion protection systems — Part 1: Determination of explosion indices of combustible dusts in air

0 Introduction

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

    a)   the physical and chemical properties of the dust;

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

    c)   the homogeneity and turbulence of the dust/air mixture;

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

    e)   the geometry of the container;

    f)   the temperature, pressure and humidity of the explosive dust/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 2: Determination of explosion indices of combustible gases 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)   low turbulence conditions prevailing in a gravity-fed silo;

    b)   high turbulence conditions prevailing in a grinder or micronizer.

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 dusts suspended in 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 dust/air explosions after ignition of the 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 dust/air mixture, it should not be concluded that the dust in question cannot explode. The interpretation of such cases should be left to specialists in the field of explosions and explosion protection.

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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 m³.

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 m³.

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 dust 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

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

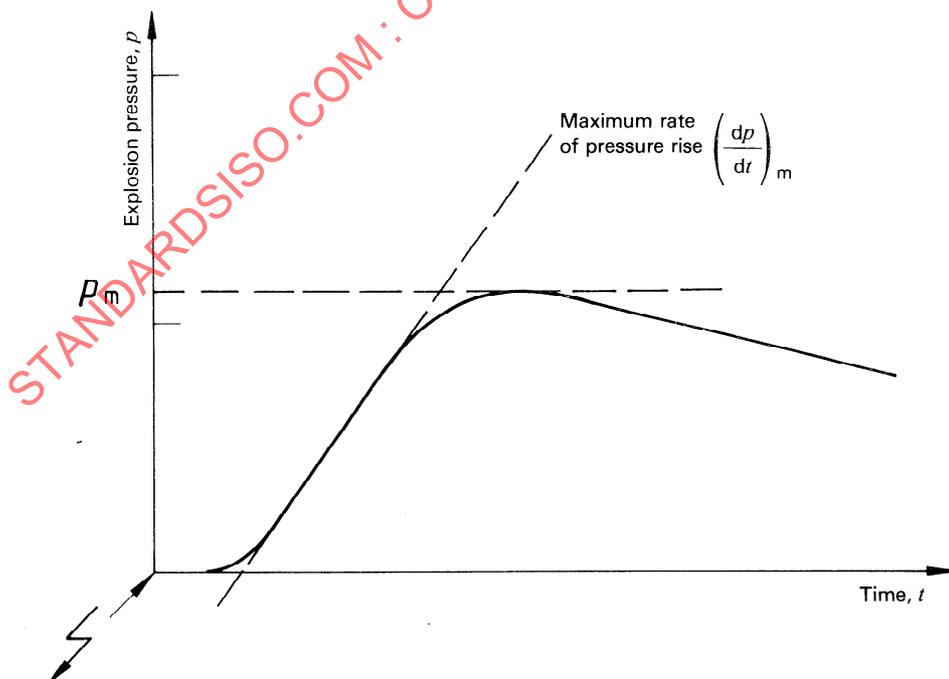NOTE — For dust/air mixtures, $K_{max, quiescent}$ is a theoretically derived parameter.

Figure 1

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1) 1 bar = 10⁵ Pa

4 Test method

4.1 General

The apparatus described in this part of ISO 6184 has been chosen as the reference apparatus and is suitable for the evaluation of explosion indices of combustible dusts which have a particle size not exceeding 63 μm and a moisture content not exceeding 10 % (*m/m*).

NOTES

1 In practice, dust with larger particle sizes and/or higher moisture contents can be characterized in this standard apparatus, provided that such dust can be dispersed effectively in the explosion chamber.

2 The sample tested should be representative of the material in use in respect to particle size distribution and moisture content.

4.2 Apparatus

The apparatus consists essentially of a cylindrical explosion chamber with a volume of 1 m³ 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 mm².

The ignition source comprises two pyrotechnic igniters with a total energy of 10 kJ and arranged to ignite after a fixed ignition delay, corresponding to a turbulence index, t_v, of 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

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. Ensure that the explosion chamber is at atmospheric pressure. Start the pressure recorder and then activate the sample container valve followed by the igniter. After each test, clean the explosion chamber by purging with air.

Repeat this procedure for a wide range of dust concentrations to obtain curves of p_m, in bars, and K, in bar metres per
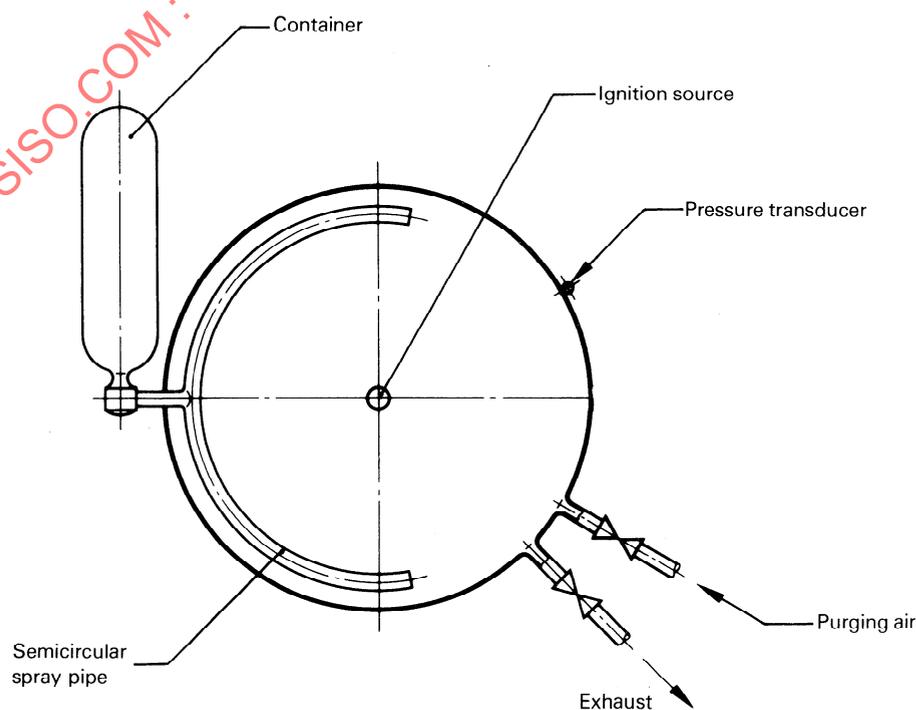

Figure 2

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second, versus dust concentration, in kilograms per cubic metre, to determine p_{max} and K_{max} respectively (see figure 3).

NOTE — The explosion pressures attain their maximum values if ignition occurs as soon as all of the dust is effectively dispersed in the explosion chamber. For this apparatus, this is achieved with an ignition delay (t_v) of 0,6 s. The ignition delay (t_v) corresponds to a specific level of turbulence determined by the turbulence index (T_u) and hence has an influence on the measured value of K_{max}. Since some turbulence always exists in a dust/air suspension, T_u is necessarily greater than 1. The effect of increasing t_v is to lower the K_{max} value and vice-versa. (See figure 4.)

4.4 Alternative test methods

The explosion indices of combustible dust/air mixtures can be determined using alternative test equipment and/or test procedures providing that it has been proven that such methodology gives results directly, or by calculation, that are commensurate (± 20 %) with the results obtained using the 1 m³ apparatus for at least 5 dusts from each of the following explosibility ranges:

$K_{max} < 200$ bar·m/s

$K_{max} \leqslant 300$ bar·m/s

$K_{max} > 300$ bar·m/s

NOTE — In cases where the test apparatus is not to be used to determine the explosion indices of dusts in certain explosibility ranges, it is possible to reduce the number of dusts tested in these ranges.
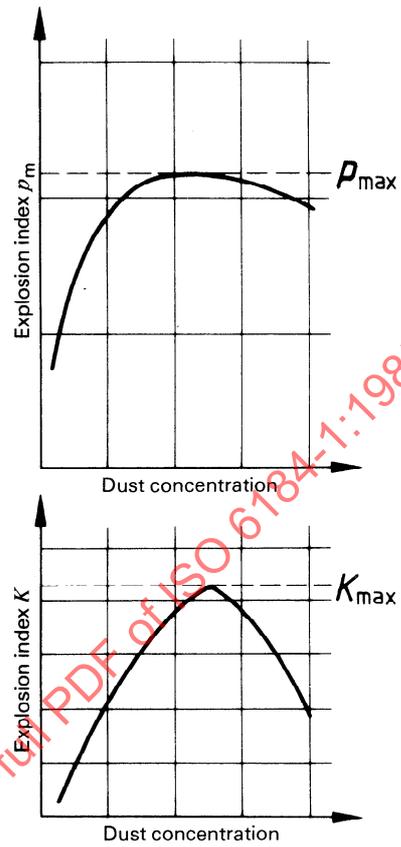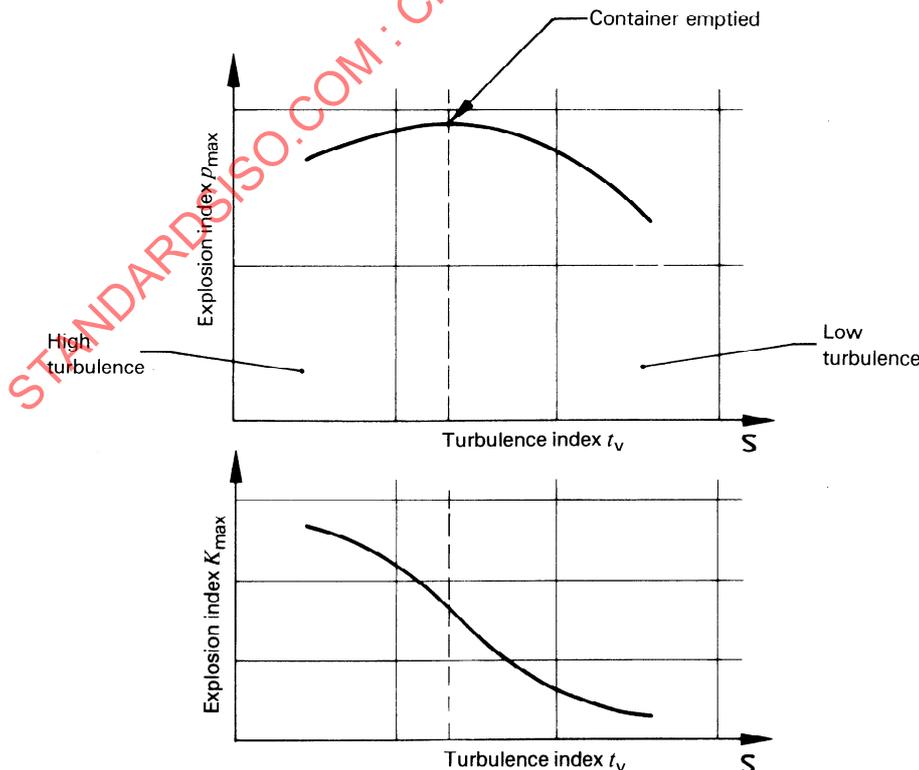

Figure 3

Figure 4