1m^3 Explosibility (P_{max} and K_{st}) Test (Exp)

INTRODUCTION

The explosive behavior of a dust can be determined in a 20 liter spherical vessel, and described in terms of maximum explosion pressure (P_{max}) and maximum rate of explosion pressure rise (K_{st}). However, this size vessel is subject to 'over-driving' samples due to the small vessel volume and the strong chemical ignition source used. A better estimate can be obtained by testing in a larger volume vessel, such as the 1m^3 vessel using a 10kJ ignition source, according to ISO 6184/1, "Determination of Explosion Indices of Combustible Dusts in Air", and ASTM E1226 "Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts".

BACKGROUND

The potential severity of a dust explosion is quantified by measurement of the pressure and rate of pressure rise due to the explosion. These measured parameters are a function of:

- The physical and chemical properties of the dust (particle size distribution and chemical composition);
- The concentration of dust in the dust/air mixture;
- The homogeneity and turbulence of the dust/air mixture;
- The type, energy and location of the ignition source;
- The geometry of the vessel in which the explosion is occurring;
- The initial pressure and temperature of the dust/air mixture.

Therefore, it is important to use a standard laboratory test method to measure these explosion parameters.

A typical pressure time curve from a dust explosion in the 1m^3 chamber is shown in Figure 1.

P_{ex} is the maximum pressure observed during the course of the explosion. Similarly, $(dP/dt)_{ex}$ is the maximum rate of pressure rise during the explosion. As noted above, P_{ex} and $(dP/dt)_{ex}$ vary as a function of several parameters. In the standard test method used, the homogeneity and turbulence, the type energy and location of the ignition source, vessel geometry and initial conditions are kept constant. The effect of varying concentration on P_{ex} and $(dP/dt)_{ex}$ is then observed for a given dust. A series of tests are conducted over a range of concentrations and P_{max}, the maximum explosion pressure, and $(dP/dt)_{max}$, the maximum rate of pressure rise are determined from the series of tests.

An additional explosion parameter, K_{st} can also be determined from a series of tests. As shown below, K_{st} is the maximum rate of rise normalized to a 1m^3 volume.

$$K_{st} = (dP/dt)_{max}\ V^{1/3}$$

Where: P - pressure, bar
t - time, seconds
V - volume, m^3
K_{st} - bar.m/s

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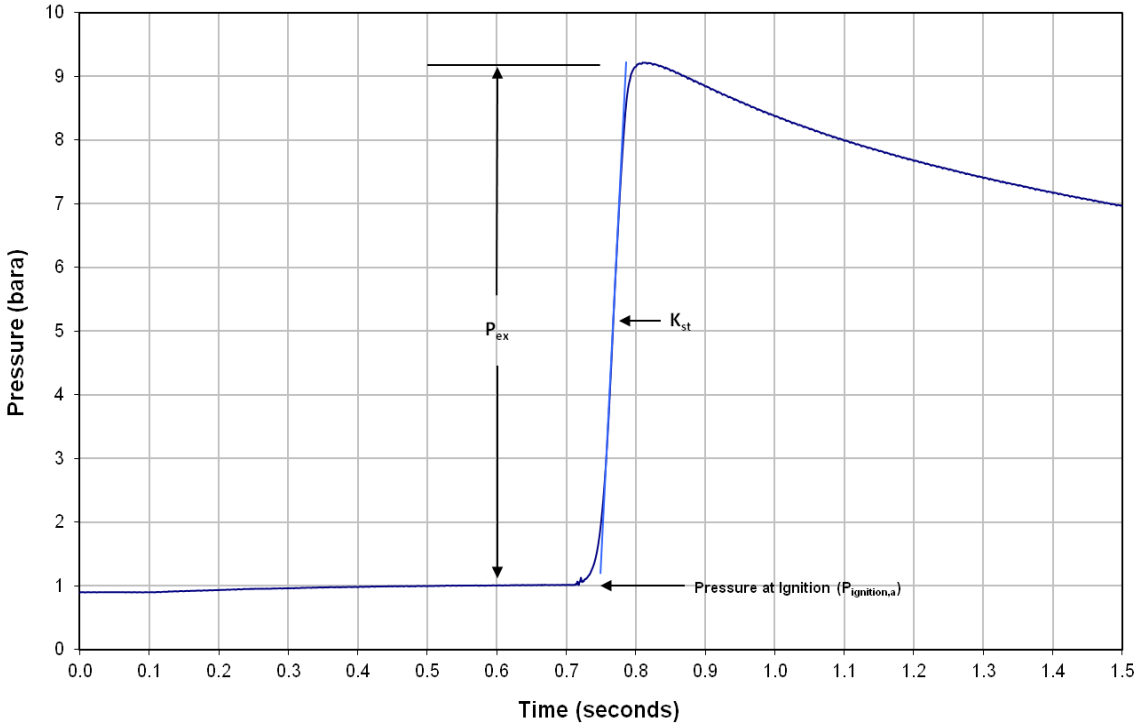

Figure 1: Pressure vs. Time from Dust Explosion in 1m³ Chamber

EXPERIMENTAL

A schematic representation of Fike Corporation's 1m³ vessel is shown in Figure 2. The vessel is spherical in shape. The dust is injected into the partially evacuated test vessel using a 5 liter discharge vessel charged to 290 psig. The 1m³ vessel's initial pressure is set to allow the pressure to reach 1 bara by the time of ignition. The ignition source is located at the center of the spherical explosion chamber. The standard ignition source in the 1m³ vessel consists of two 5kJ Sobbe chemical igniters (10kJ total energy). A standard test method for the measurement of pressure and rate of pressure rise for combustible dusts in the 1m³ vessel has been established by ISO 6184/1 and EN 14024/1,2.

Two pressure transducers are used to observe the pressure history of the explosion. Proprietary operating software is used to control the operation of the ball valve and the ignition of the dust cloud, as well as to collect pressure data from the transducers during each test. The time delay between injection and ignition is held constant in accordance with previous vessel calibrations. At the time of ignition, the dust cloud is at room temperature (~25° C) and a normal pressure of 1.0 bara ±5%. A filtered exhaust is attached to the chamber to allow safe post-explosion cleanup of the chamber.

The general procedure for the experiments are shown below:

A. A weighed amount of dust is placed in the loading cylinder.
B. Two 5kJ chemical igniters are placed at the center of the chamber.
C. The chamber is sealed.
D. The chamber is partially evacuated to facilitate ignition at 1.0 bara ±5%.

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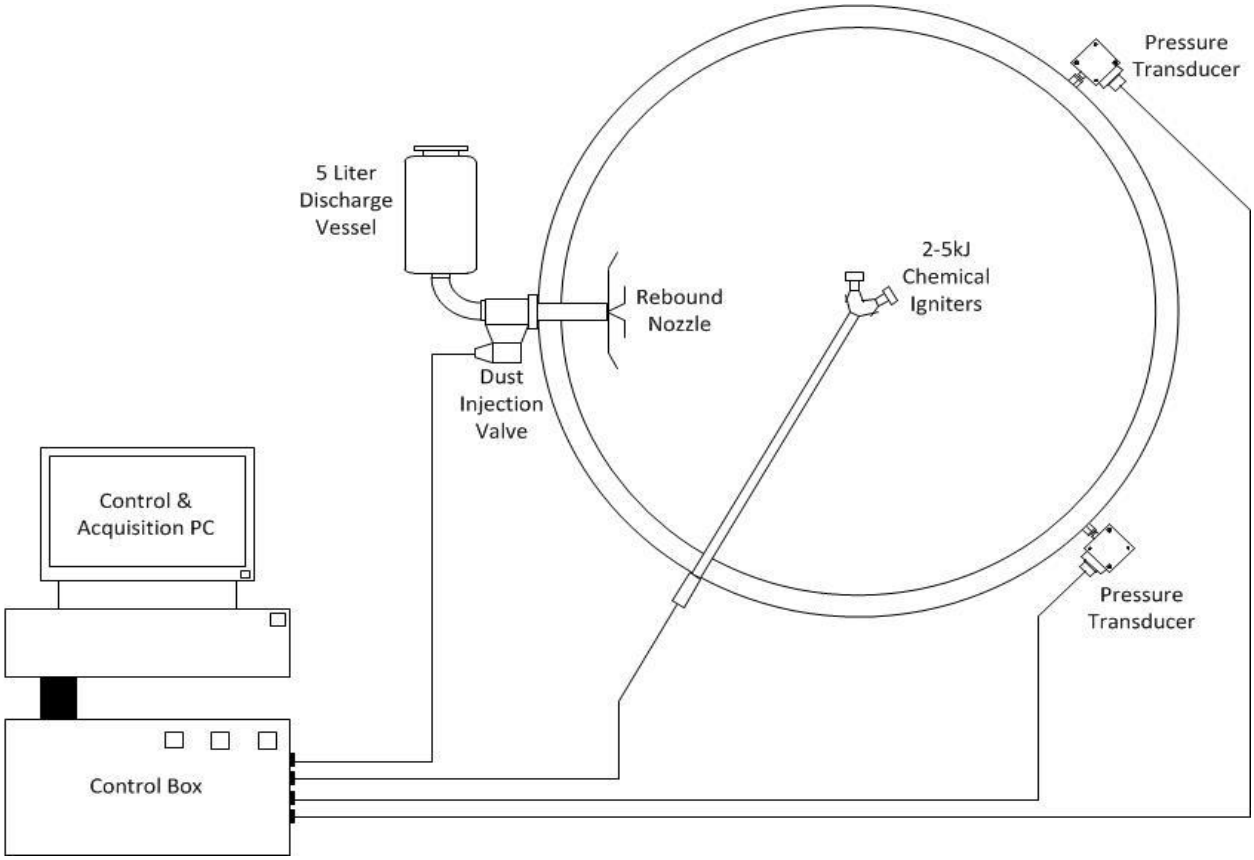
E. The air discharge vessel is pressurized to 290 psig.
F. The operating software synchronously controls injection, ignition, and data acquisition during the combustion process.
G. Data is processed and test logs are updated.
H. The chamber is flushed with air.
I. The chamber is opened and cleaned thoroughly prior to the next test.

The initial test series (Series 1) is varied in concentration until the maximum values of P_{ex} and K_{st} are determined. Once the 'worst case' conditions are determined, two additional series of tests are conducted at the concentration where the maximums were found and at one concentration on each side of the maximums.



1m^3 Chamber

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