20 Liter Explosibility (P_{max} and K_{st}) Test (Exp)

INTRODUCTION

The explosive capability of the explosion behavior of a dust sample can be determined in a 20 liter spherical vessel. This capability can be described in terms of maximum explosion pressure (P_{max}) and maximum rate of explosion pressure rise (K_{St}). Tests are conducted according to ASTM E1226 "Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts". Knowledge of these values is required for the design of protection systems against accidental explosions, such as explosion vents as described by NFPA 68.

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 a 20 liter 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; homogeneity, turbulence, energy type, 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 to determine P_{max}, the maximum explosion pressure, and $(dP/dt)_{max}$, the maximum rate of pressure rise.

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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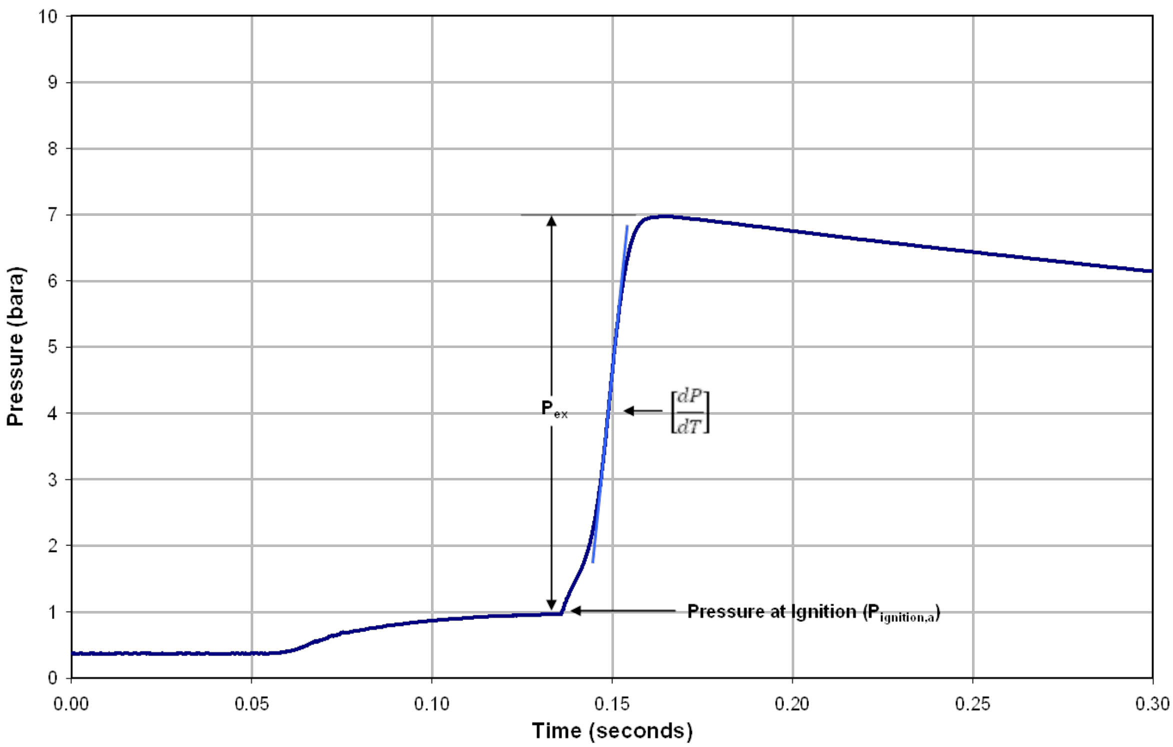

Figure 1: Pressure vs. Time from Dust Explosion in 20 Liter chamber

EXPERIMENTAL

A schematic of the apparatus used to measure the dust explosion parameters in compliance with ASTM E1226 is shown in Figure 2. The explosion chamber used is a 20 liter sphere containing a dispersion nozzle. The dispersion nozzle is connected to a sample loading cylinder and a 0.6 liter air discharge vessel. During an experiment, dust is placed in the loading cylinder and the air discharge vessel is pressurized to 290 psig. The dust is dispersed through the holes in the dispersion nozzle into a partially evacuated explosion chamber by activating the ball valve in between the discharge vessel and the sample cylinder. The resulting dust cloud is ignited with chemical igniter(s) placed at the end of the ignition leads. The ignition source is located at the center of the spherical explosion chamber.

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.

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The general procedure for the experiments are shown below:

A. A weighed amount of dust is placed in the loading cylinder.
B. Chemical igniter(s) 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%.
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 vented through the filtered exhaust and 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.

To compensate for cooling effects from the walls of the 20 liter, a mathematical correction is performed on the measured P_{max}, if the P_{max} is greater than 5.50 bar. The reported value shown on the Fike issued test report reflects this calculation, if it applies. The equation for the correction is taken from the Appendices of ASTM E1226 "Standard Test Method for Pressure and Rate of Pressure Rise for Combustible Dusts" and is shown below.

$$P_{max} \text{ Corrected} = 0.775\, P_{max}^{1.15}$$

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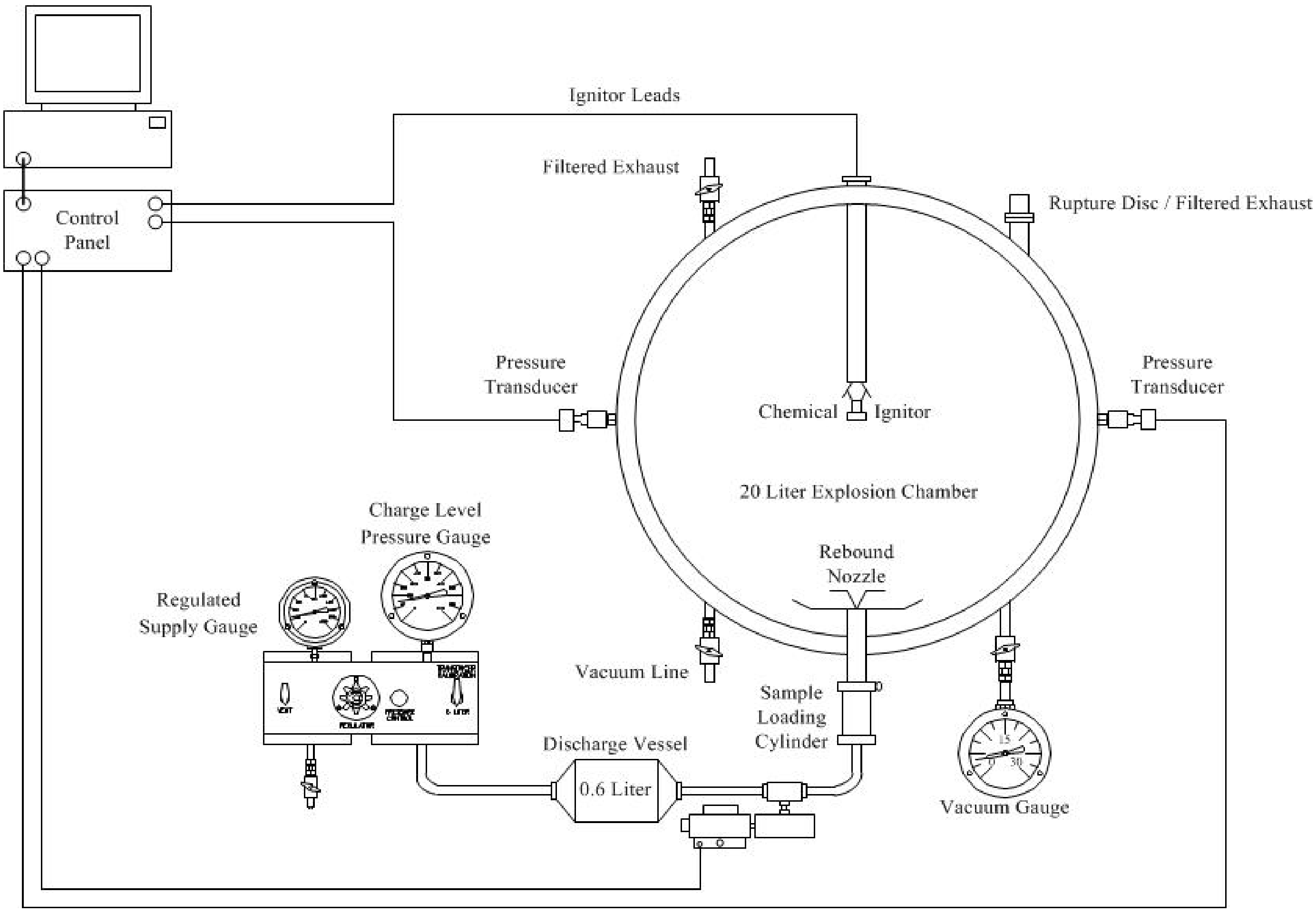

20 Liter Apparatus

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