20 Liter Minimum Explosible Concentration Test (MEC)

INTRODUCTION

In addition to the maximum explosion pressure (P_{max}) and the maximum rate of explosion pressure rise (K_{St}), the explosive behavior of a dust can be described by the minimum explosive concentration (MEC). MEC is the lowest concentration of dust in the air necessary to allow the propagation of a deflagration wave. MEC data may be used to determine safe process flow conditions. The standard test method is ASTM E1515, “Standard Test Method for Minimum Explosible Concentration of 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 a 20 liter chamber is shown in Figure 1. $P_{ex,a}$ is maximum absolute pressure observed during the course of the explosion. P_{ex} is the maximum gage 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 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.

Also shown in Figure 1 is a typical pressure vs. time curve produced by the standard ignition source. As dust concentration is lowered P_{ex} is also lowered and becomes the same order of magnitude as the pressure due to the ignition source, $\Delta P_{igniter}$. In determining minimum explosive concentration, the effect of the ignition source is taken into consideration by determining the relationship between dust concentration and the Pressure Ratio (PR). The pressure ratio (PR) is calculated using the following equation.

$$PR = \frac{P_{ex,a} - \Delta P_{igniter}}{P_{ignition,a}}$$

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Where:
$P_{ex,a}$ = Maximum absolute explosion pressure
$\Delta P_{igniter}$ = Pressure increase due to the ignition source
$P_{ignition,a}$ = Absolute vessel pressure at the time of ignition

The criterion for ignition is a PR ≥ 2 for dust explosions occurring at a normal pressure of 1 bara.

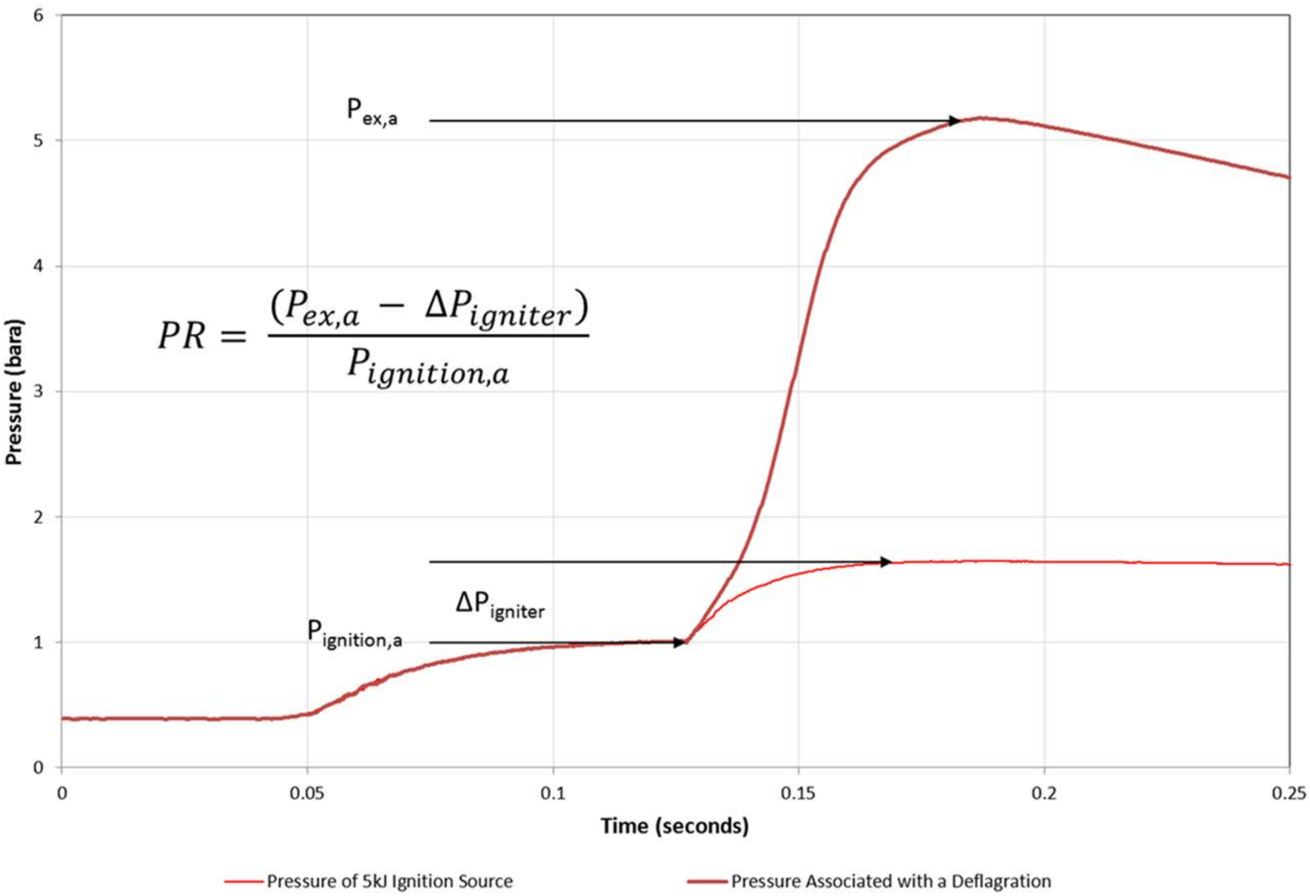

Figure 1: Pressure Ratio Ignition Criterion

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EXPERIMENTAL

The apparatus used to measure the minimum explosive concentration 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 was ignited with a chemical igniter 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.

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.

Each concentration being tested decreases until the pressure criteria of PR ≥ 2 is not met. Once a non-ignition is observed, two replicate tests are performed at the same concentration where the non-ignition was observed. The reported MEC value is the lowest concentration tested that did meet the pressure criteria of PR ≥ 2.

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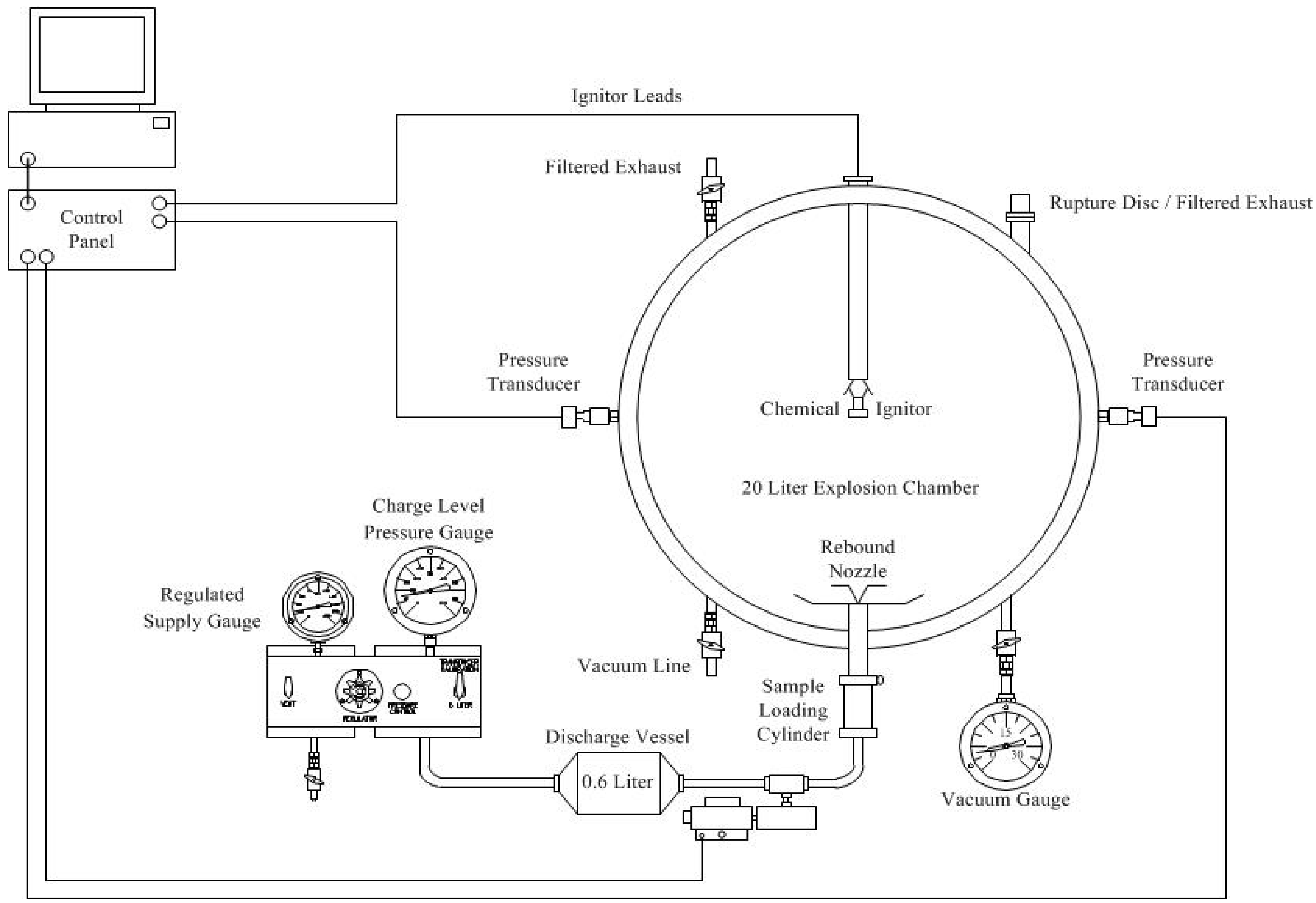

20 Liter Apparatus

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