Chemical Process Safety (52:187) Spring 2005

Laboratory Experiment 3: Vapor & Dust Explosions/Vent Sizing

Due Wednesday, March 30

- You must wear safety glasses in the laboratory.
- Each person needs to record all experimental data.

Dust Explosions

The objective of this experiment is to observe and characterize the explosion characteristics of three dusts: flour, cornstarch, and baking soda.

Procedure: Modified Hartman Tube Apparatus

1. Ensure your dusts are thoroughly dry. Weigh a 1200 mg sample of each of the three dusts. Record the actual mass used and the physical properties of each dust.
2. Place one sample in the glass tube, distributing the material evenly over the base.
3. Fill the pressure chamber with air at 7 bar by pressing the **white Air In** button.
4. Switch on the ignition source by pressing the **yellow Ignition** button.
5. Quickly introduce the air from the pressure chamber into the glass tube by pressing the **Air Out** button.
6. An explosion is recorded if a dust fire occurs or if the indicating instrument registers an opening of the hinged cover. Only dust explosions that give a "1" indication on the control box are St-1 Class dusts. If a "0" or "2" is indicated, additional tests in a more expensive apparatus are necessary to determine the dust St Class.
7. Record the indication number given on the control box and your visual observations.

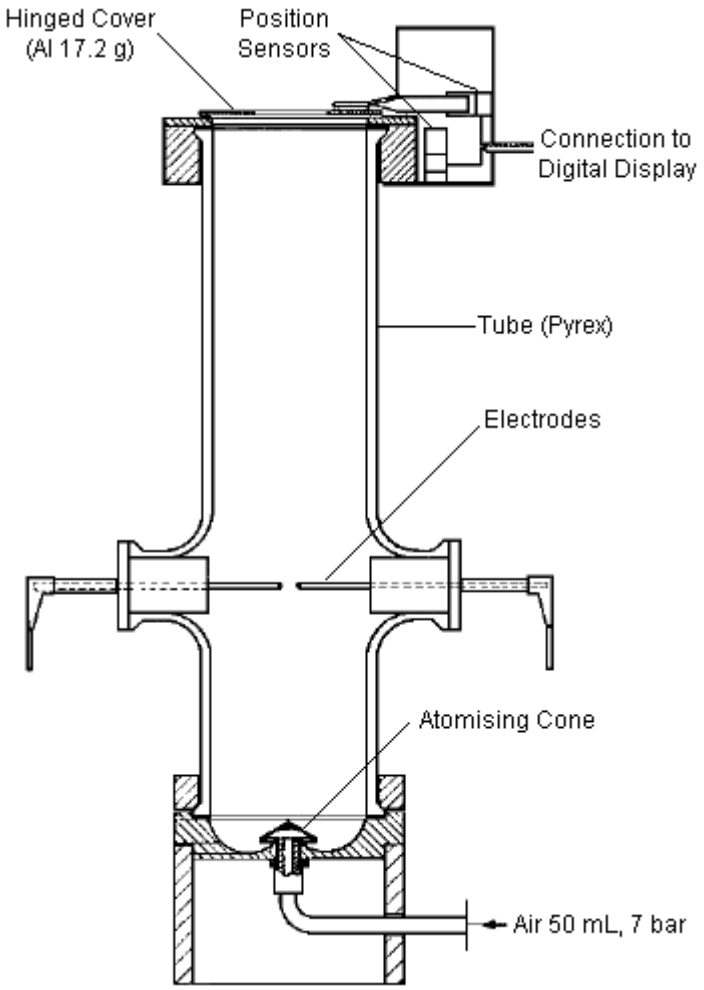
Vapor Explosions and Deflagration Vent Sizing

The purpose of this experiment is to calculate the gas deflagration index K_g for propane and to size a deflagration vent for a process vessel using a given set pressure and maximum allowable working pressure (MAWP).

Procedure: FlameTec

1. Open the FlameTec Test software and select Run.
2. Ensure the vent on the FlameTec vessel is shut and the low-pressure transducer isolation valve is open.
3. Initiate propane flow by opening the feed valve. The pressure in the vessel will be shown on the screen. Shut feed valve when the desired pressure is obtained. The total tested pressure in psig is 14.7 + (propane partial pressure).
4. Set data acquisition parameters. Recommended parameters are:
   - Total length of time to take data: 2 seconds
   - Data acquisition rate: 1 kHz (1000 points/sec)
   - Igniter delay time: 0.2 seconds
5. Select end monitoring and begin test mode by clicking the corresponding **red button** on the computer screen.
6. Name the data file after your group number.
7. Shut the low pressure transducer isolation valve.
8. Connect the igniter cable.
9. Arm the igniter by **flipping the switch** on the FlameTec control box.

10. Start the test by clicking on the **green start button** on the computer screen. When the test is complete, **vent the vessel in a hood. Vessel may be full of smoke and/or unreacted propane.**
11. Clean the vessel well and **replace the igniter element** before conducting the next test.



Modified Hartman Tube Apparatus (Volume = 1200 mL)

Some things to include in your report:

Discuss the conditions under which a dust explosion could occur and the characteristics that the dust must have to be explosive. Relate both to industry.

What is the LEL/UEL for most dusts? Is the dust concentration (in g dust/m^3) you used in the lab within the range of explosion limits for most dusts?

Describe the St dust classification system. What type of explosion was modeled using the Hartman Apparatus? What are the properties of this type of explosion?

What were the physical differences between the three powders tested? Explain why the powders either created or did not create an explosion.

What is the concentration of the propane in the vessel? Is it inside the flammability range for propane?

Define deflagration and detonation. What determines which of these types of explosions will occur? What are some parameters that significantly affect the behavior of explosions? Talk briefly about deflagration venting for dust & vapor explosions.

Determine and tabulate the maximum pressure and the maximum rate of pressure increase in the FlameTec experiment. Based on the maximum pressure obtained in the FlameTec apparatus, was this explosion classified as a detonation or a deflagration (based on the guidelines provided in Crowl & Louvar)?

Using the "Cubic Law" relationship with the volume of the FlameTec vessel (1 gallon), calculate the gas deflagration index K_g for propane and compare with the literature value. How do they compare? What are some factors that could cause K_g to vary for a given material? Based on the relationship given in C&L, calculate the expected maximum rate of pressure increase (in bar-m/sec) in a field-scale vessel of a given volume and a comparable propane partial pressure.

Under what conditions would the results of this experiment not represent actual process results?

Using your specified vessel volume, size a deflagration vent for a propane vessel for the set pressure and MAWP provided to your group in lab.

Reference for diagram:

Safety Testing Equipment: Screening Tests & Test Procedures Adolf Kuhner AG, November 1997.

By including the above information, you will earn most of the total points available for the lab report. Beyond that, reports will be graded based upon how well you connect ideas, your understanding of what is going on in the experiment, how well you describe the relevance of the experiment and its results to chemical process safety, report organization, and grammar. **MAKE SURE YOU PROOFREAD!** If you have any questions, feel free to talk to either TA or send an email.

Special attention will be made to organization of the Discussion Section. We do not simply want a list of answers to the questions!

Vessel volume =

Set pressure =

MAWP =