

Determination of Explosion Limits, Maximum Explosion Pressure and Maximum Rate of Pressure Rise for an Air- Fuel Gas Explosion

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Abstract: Explosions, whether or not followed by fires are destructive phenomena, with major social and economic implications, especially given the current technologies. Therefore, the risk assessment associated with each explosion is the duty of every employer to ensure the safety and health by implementing risk management requirements prescribed by regulations. To assess the risk of explosion and explosion expertise of such events, it is necessary to know the parameters of explosion characteristics of air mixtures - flammable substances. Development of methods for determining the explosion characteristic parameters of air - combustible substances mixtures increase the capacity of expertise in explosions, the extension of knowledge about the explosion phenomenon and increase the occupational health and safety by using experimental data obtained in developing the explosion proof protection measures. Determination of explosion parameters plays an important role in the primary phase of explosion risk assessment and conformity assessment stage equipment and protective systems intended for use in potentially explosive atmospheres.

Keywords: explosion, explosion limits, maximum explosion pressure.

1. Introduction

Technology development resulted in solving numerous aspects of industrial risks, but nevertheless still appear new risks and a number of risk factors including risk of explosion which is impressive with serious consequences (human and material losses) which strongly influences social relations and indirect costs of the finished product. Such situations justifies the high interest to the problem of formation of explosive mixtures with air which takes the form of fine dispersion of gas, vapor, mist or dust. This situation show interest to justify high oil explosivity problem and not only illustrated by studies addressing such research and is justified by the need to give the answer to three problems: prediction, prevention and protection of the events (accidents) involving explosions of chemical compounds.

The concern to avoid accidental explosions and limit damage caused by them (when explosions can not be suppressed) is a research direction more consistent as the increase risks of such incidents. Increased consumption of fuel, solvents and other flammable substances resulted in increasing the number of units that can form explosive mixtures in activities during manufacture, storage, handling or transport. Risk assessment formation of such mixtures, the risks of explosions and their consequences is necessary both to protect people and equipment, as well as the environmental emissions of pollutants generated by combustion compounds. Explosions, followed or not by fire, are destructive phenomenon, with major social and economic implications, especially given current

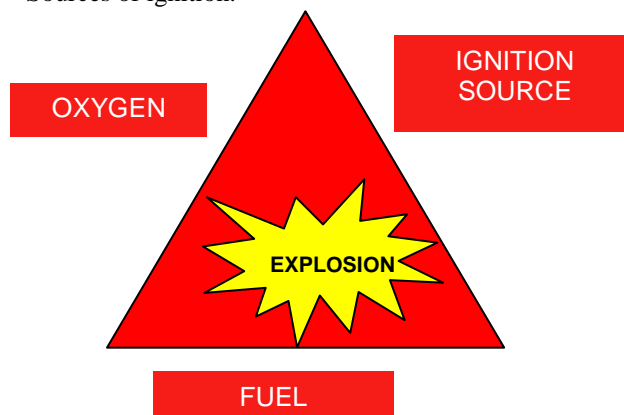
technologies. Therefore, risk assessment associated with explosion is the duty of every employer to ensure the safety and health by implementing risk management requirements prescribed by regulations.

In order to assess the risk of explosion and explosion expertise type events, it is necessary to know the parameters of explosion characteristics of air mixtures - flammable substances.

Any chemical reaction accompanied by the sudden release of a large amount of heat is named explosion and systems that can support this process are called explosive or flammable systems [1 - 5].

Probability of appearance of an explosion involves the simultaneous existence of three factors:

- Combustible (flammable gaseous substance and / or dust)
- Oxidizing (oxygen from air)
- Sources of ignition.



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Process characteristic parameters of "explosion" to be determined are:

- Lower explosive limit (LEL) which is defined as the lowest concentration of fuel in the explosion can occur independently and can propagate throughout the volume of fuel mixture - oxidant, even after the action of the ignition source of the explosion stopped

- Upper explosive limit (UEL) which is defined as the highest fuel concentration value at which explosion has yet taken place, with the same restrictions as above, the definition LEL.

Explosion limits of combustible gas mixture are defining oxidant concentration range (at constant temperature and pressure) where an initial explosion can propagate independently in all of the explosive mixture.

- Maximum explosion pressure is the highest pressure that occurs during of an explosion of a flammable mixture in a closed vessel.

- Maximum pressure rise $(dp / dt)_{\max}$ - maximum slope of the curve pressure / time during a flammable mixture explosion in a closed vessel.

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

2. Experimental

The apparatus named K-SEP, (Fig. 1) used for determining explosion parameters for air - combustible mixtures, is composed from a spherical vessel explosion, explosion resistant executed from stainless steel with a volume of 20 dm³. A water mantle is designed to absorb heat from the explosion.

Preparation of the explosive mixture of known concentration was performed by calculating the partial pressure of the fuel, with the help of the apparatus software, fig. 2

The fuel used for the experiment was methane gas due to the fact that most accidental explosions occur due to this gas.

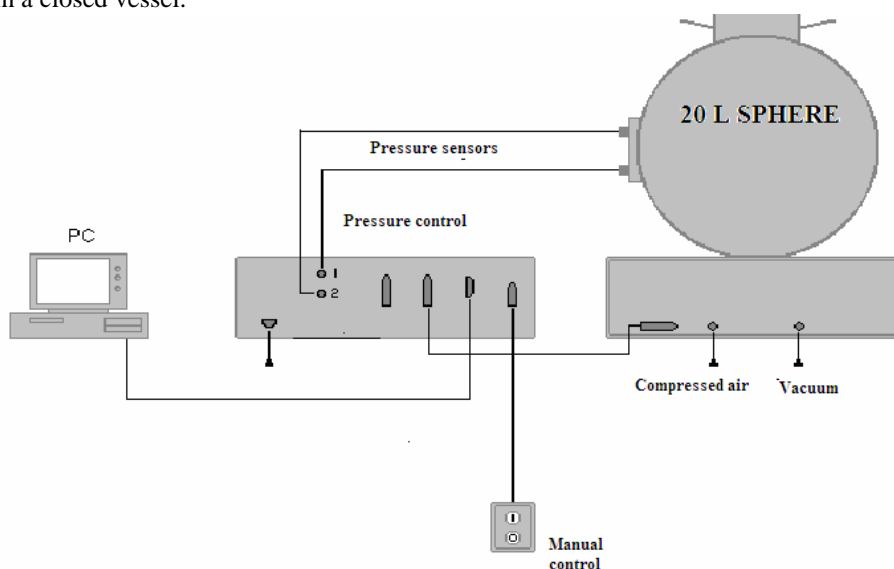


Figure 1. Schematic diagram for explosion parameters determination installation

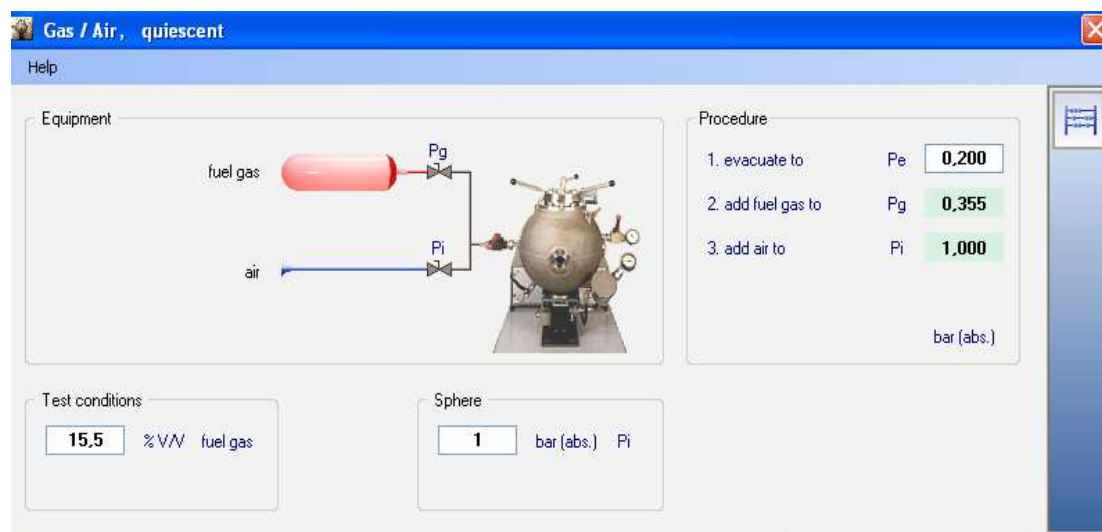


Figure 2. Method for preparation of the explosive mixture

3. Results and Discussion

The experiments in this paper focuses on the calibration of the system, and the data obtained are preliminary data, in order to continue the research on explosive parameters for combustible – air explosion.

The experiments conducted for determining the explosion limits were made in accordance with the SR EN 1839 standard, "The determination of the explosion limits".

In the figure 3 it is presented maximum explosion pressure curve for an explosion of methane in concentration of 9,8 %.

This concentration of methane have been selected, because it is known from the literature to be the most reactive from the explosion domain of the methane, in order to compare the values obtained with the results from literature.

In Table 1 are presented obtained data in this experiment that took place during methane-air explosion with methane concentrations of 4,5 %, 5 %, 9,8 % and 15 % and 15,5 % volume.

The LEL, and UEL, had been determined at 5 and 15 % of methane, considering that the maximum explosion pressure was bigger with at least 5 % than the overpressure created by the ignition source only in air, the condition from SR EN 1839 for a mixture to be considered explosive.

The maximum explosion pressure for the most reactive concentration of methane, stoichiometric ratio, was not in accordance with the literature data, Pmax from literature 8,47 bar [6], and in our experiment only 6,1 bar, that leading to the conclusion that the system has to be reevaluated, in order to achieve the best possible correlation with literature data.

TABLE 1.

CH ₄ % vol.	4,5 %	5 %	9,8 %	15 %	15,5 %	air
Pmax [bar]	1,6	6	6,1	6	1,1	1,6
(dP/dt)max [bar/s]	7	176	222	217	4	5
Kmax [mbar/s]	1,9	47,7	60	58,8	1	1,35

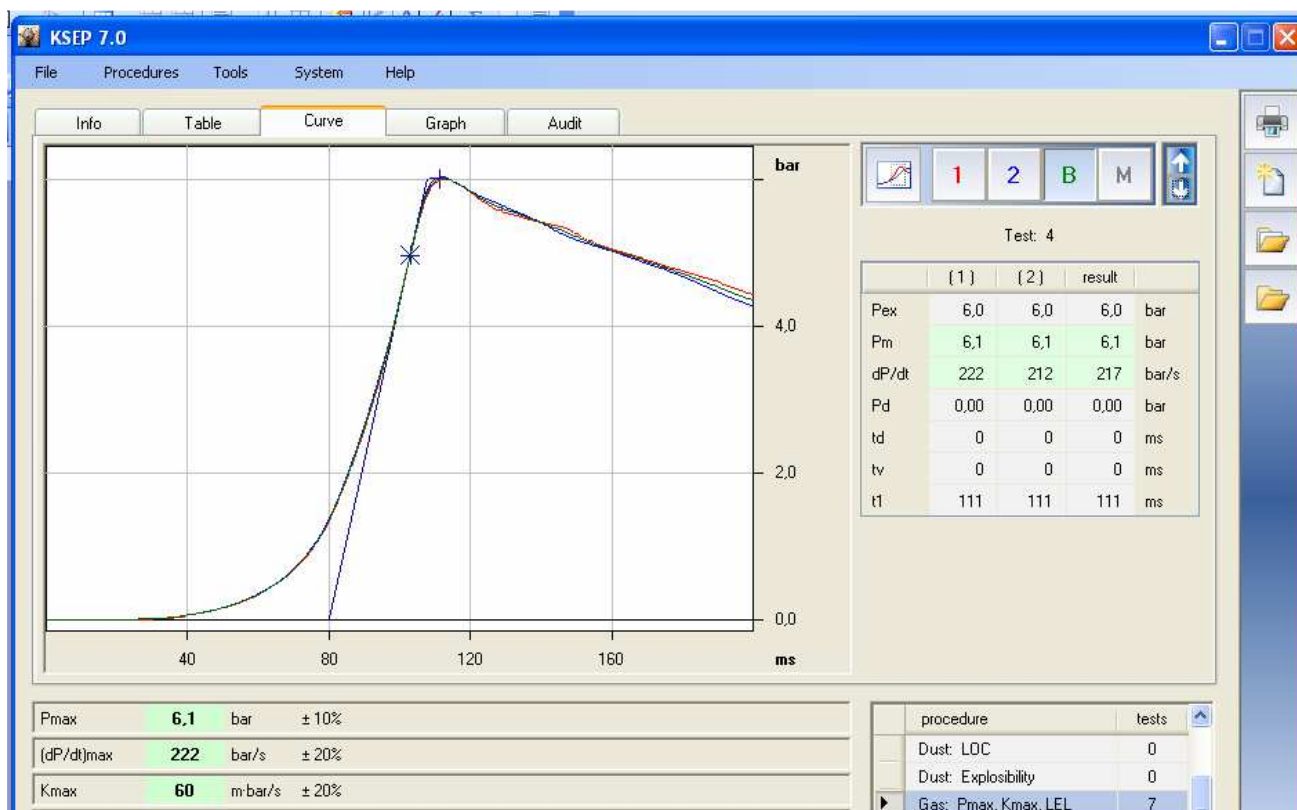


Figure 3. Maximum explosion pressure in time for 9.8 % vol. methane explosion

4. Conclusions

To assess the risk of explosion and explosion expertise type events, it is necessary to know the parameters of explosion characteristics of air - flammable substances mixtures.

Experiments conducted in this paper focuses on the explosive behavior of methane - air to determine the explosion parameters.

Experiments were preliminary tests to improve the system in order to achieve the best possible correlation with literature data for further research on the determination and assessment of explosion characteristic parameters in air - flammable substances mixtures.

In the future, we want to study the behavior of explosive hybrid mixtures (such as coal dust-methane-air mixture).

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