NECESSITY TO VERIFY THE VENTILATION SYSTEMS OPERATING IN POTENTIALLY EXPLOSIVE AND/OR TOXIC ENVIRONMENTS

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ABSTRACT: *To control the atmosphere of industrial enclosures are used complex installations for ventilation that typically include ventilators, routing systems, regulating systems, wetting, heating / cooling, dedusting, etc. Ventilation systems are designed in order to maintain under the maximum permissible limit the concentrations of gases, mists, powders or dusts, generated by industrial processes. During their operation may occur structural changes or operating system entailing changes in functional parameters and specific of the ventilator and therefore the risk of occurrence for potentially explosive and / or toxic atmospheres. For this reason it is necessary to check them regularly. Checking ventilation systems aims to achieve and maintain an optimal environment for carrying the activity, protection of life, bodily integrity and health of workers and others involved in the work process. Verification activity of the ventilation systems has strong preventive role mainly in terms of risk of explosion because of the three elements that can lead to an explosion occurrence, ventilation systems can provide fuel (gases, vapors, dusts / powders, mists) respectively initiation source (hot surface, flame, mechanic sparks, electrical sparks, static electricity, etc.).*

KEY WORLDS: ventilation, explosive atmospheres, toxic environments

1. INTRODUCTION

Within the work environment there may occur factors generating toxic or explosive atmosphere which have drastically and sometimes dramatically consequences upon the workers. In order to ensure the occupational health and safety of workers in all aspects related, there have to be prevented occupational risks, their avoidance or the assessment of risks which cannot be avoided, respectively fighting against risks at their source.

2. EXPLOSION RISK

In essence, the explosion is an extremely rapid physical-chemical process of flammable substance or compounds combustion, accompanied by a rapid change of their potential energies into mechanical work. The mechanical work is the result of instant increase of the volume of gases formed at the moment of the explosion and their instant increase of temperature and pressure. Generation and violent release of gases is specific for the explosion and it occurs in all three types of explosions: mechanical (physical), chemical and atomic.

Chemical explosions of air-fuels mixtures may be grouped into homogenous explosions and heterogeneous explosions.

Heterogeneous explosions are explosions which ignited in a point of the mixture, spread step by step on its own support, through the capacity of auto-maintenance of the reaction. It is understood that a group of molecules under the action of an external impulse decomposes, and then the resulted energy is sufficient for generating repeated decomposing in the neighbouring layers. So, the explosion spreads like a wave.

A homogenous explosion is a chemical reaction which takes place in a homogenous mixture that has in any moment strictly uniform temperature and concentrations, and the reaction speed (in the sense of chemical kinetics) is the same in all points of the system; this speed increases until it reaches a high value, meaning an explosion [1].

Explosions may occur anytime there are simultaneously fulfilled the conditions:

- flammable/combustible (fuel) substances or mixtures present a high level of dispersion in air;

- concentration of flammable substances or mixtures in air (oxygen carrier) is found between the explosion ranges (lower or higher);
- the quantity of explosive atmosphere (air-fuel mixture) is dangerous at a moment; there is considered to be dangerous a compact explosive atmosphere of minimum 10 dm^3, formed in an enclosure (room), regardless of its size;
- the ignition source exists and is efficient (high enough temperature and energy) for ensuring the activation of the molecules in order to ignite and spread the fast combustion reaction.

The necessary conditions to achieve an explosion are presented in figure no.1.

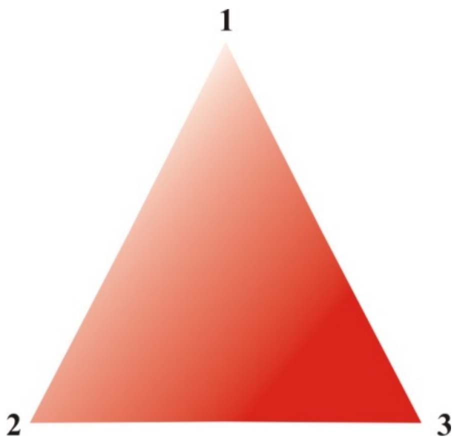

Fig. 1. Explosion triangle

Legend
1. fuel (gases, vapours, dusts/powders, mists);
2. oxygen carrier (oxygen, oxidant substances);
3. ignition source (hot surface, mechanical sparks, electrical sparks, static electricity, etc.).

3. VENTILATION INSTALLATIONS VERIFICATION

Execution projects comprise systems for preventing and fighting against risk factors which may occur during the development of technological processes. Based on the approached knowledge of the type and quantity of noxious which can be released in the enclosure, the designer includes ventilation installations for limiting or removing the risk of potentially explosive and/or toxic atmosphere occurrence.

Based on the execution project, the builder mounts installations for ventilation depending on the technical specifications of the intended location.

Depending on the technical specifications, the ventilation installations foreseen may contain tubing or not. The ones containing tubes may be single line or branched. Also, they can be equipped with one or more fans.

In operation, the operational parameters of fans, respectively the tubing encounters changes which may lead to the increase in gas concentrations, vapours, powders or mists.

For avoiding the risk of potentially explosive and/or toxic atmosphere, the ventilation installations must be verified.

The verification of ventilation installations aims to ensure and maintain an optimal environment for performing the activities, for life care, body integrity and health of workers and other persons taking part in the work process and it establishes the general provisions for the organisation of the activity for verification of ventilation installations operating in environments with potentially explosive and/or toxic atmosphere hazards.

The activity for verification of ventilation installations is applied to all companies, whose activity is susceptible to generate potentially explosive and/or toxic atmospheres, in order to ensure the conformity of operational parameters achieved by the ventilation installations with the ones declared by the user.

The activity for verification of ventilation installations has a major preventive role regarding the explosion hazard, mainly because one of the three elements which may lead to an explosion may be ensured by the ventilation installations, namely the fuel (gases, vapours, powders/dusts, mists), and another one being the ignition source (hot surfaces, flame, mechanical sparks, electrical sparks, static electricity etc.) [3] [4] [5] [6].

The activity for verification of ventilation installations involves the determination of parameters achieved by the installation, through measurements carried out on site, as follows:

- Air state parameters:
  - ❖ air flow velocity;
  - ❖ absolute pressure;
  - ❖ temperature;
  - ❖ relative humidity;
- Aerodynamic parameters:
  - ❖ geometry of the installation;
  - ❖ pressure loss;
  - ❖ static, dynamic and total pressure / depression;
  - ❖ circulated air flow;
  - ❖ unit/total aerodynamic resistance;
  - ❖ unit/total coefficient of air losses;
  - ❖ tightening level.
- Operational parameters of fans:
  - ❖ static pressure/depression in fan intake or exhaust;
  - ❖ achieved air flow;
  - ❖ supply voltage;
  - ❖ absorbed current intensity;
  - ❖ power factor;
  - ❖ rotation;
  - ❖ power absorbed by the engine;
  - ❖ useful power;
  - ❖ operational efficiency.

4. VERIFICATION OF AERODYNAMIC COEFFICIENTS RELATED TO VENTILATION COLUMNS

Calculation phases required for determining the aerodynamic coefficients, related to ventilation columns, R_0 and K_0, on site, are the following [2]:

a) Performing measurements for:

- air flow, in one point of the column, towards the fan, Q_1 (m^3/s);
- air flow, in one point of the column, towards the workface, Q_2 (m^3/s);
- pressure, in one point of the column, towards the fan, P_1 (daPa);
- length of the column between the two points of measurement, L (m);
- average dynamic depression (pressure) and air velocity within the column, in stations for measuring air flow;
- air temperature in the ventilation column and mining work, in stations for measuring flow;
- barometric pressure within the mining work;
- diameter and length of the ventilation column;
- distance between fans and column length related to each fan.

b) The correction fo air flow is performed

Measured flows according to the ones presented above, are brought to the standard level of 760 mmHg and 15^0C using the following equation:

$$Q_{cor} = 0{,}38 \cdot B/T \cdot Q_{mas} \qquad (m^3/s)$$

in which:

B – barometric pressure determined in the measurement point, mmHg;

T – Absolute temperature (t + 273,16), K.

c) Air flow velocity within the pipe

For each point are measured the values of dynamic depression (pressure) corresponding to the two perpendicular diameters, calculating the value of the dynamic depression in environments corresponding to each diameter.

Final average value obtained in this manner serves to the determination of air flow velocity in the column of tubes, velocity determined using the following equation:

$$V = \sqrt{\frac{2\,g\,h_d}{\rho}} \qquad (m/s)$$

in which:

g – gravitational acceleration m/s^2

h_d – final average depression (pressure), Pa;

ρ - air density, kg/m^3

Air density depends on static pressure which is specific for the flow and has the t temperature:

$$\rho = 0{,}462\frac{h_S}{t + 273{,}16}$$

If the atmospheric pressure is noted with Pa (mmHg) then the static pressure from the ventilation column is the following:

$$h_s = Pa + \frac{h'_S}{13{,}6}\ , \qquad (Pa)$$

where: h_s' - reading performed with the depression-meter (Pa)

In these conditions, air density ρ is calculated using the following equation:

$$\rho = 0{,}462\frac{Pa + \frac{h'_S}{13{,}6}}{t + 273{,}15}\ , \qquad (Kg/m^3)$$

d) Average air flow is calculated using the following equation:

$$Q_m = \frac{2Q_1 + 3Q_2}{5}\ , \qquad (m^3/s)$$

e) Air flows ration is calculated using the following equation:

$$Q_R = Q_1 / Q_2$$

f) Aerodynamic resistance of the column of L length is determined using the following equation:

$$R_c = P_1 / Q_m^2 \qquad (daPa\ s^2/m^6)$$

g) The coefficient of air losses of the column of L length is determined, using Q_R and R_C, with the relation:

$$Q_R = 1{,}02 + 0{,}585K_C\sqrt{R_C} + 0{,}15K_C^2R_C$$

h) Unit coefficient of air losses is determined using the following equation:

$$K_0 = K_C / L \qquad (m^3/s \text{ for one daPa})$$

i) The aerodynamic unit resistance is determined using the following equation:

$R_0 = R_C / L$ (daPa s^2/m^7)

5.CONCLUSIONS:

In essence, the explosion is an extremely rapid physical-chemical process of flammable substance or compounds combustion, accompanied by a rapid change of their potential energies into mechanical work. Generation and violent release of gases leads to human losses, massive material losses, respectively to stopping the technological process over a longer period of time.

The activity for verification of ventilation installations has a major preventive role regarding the explosion hazard, mainly because one of the three elements which may lead to an explosion may be ensured by the ventilation installations, namely the fuel (gases, vapours, powders/dusts, mists), and another one being the ignition source (hot surfaces, flame, mechanical sparks, electrical sparks, static electricity etc.).

For the verification of industrial ventilation fans was issued a Normative on the organisation of the activity for verification of ventilation installations operating in industrial units with explosive and/or toxic atmosphere occurrence hazard, NVIV-01-06 approved by Order of the Ministry of Economy and Finance and of the Ministry of Labour, Family and Equal Opportunities no. 1638 dated April 25th 207, respectively Order of the Ministry of Economy and Finance and of the Ministry of Labour, Family and Equal Opportunities no.393 dated may 2nd 2007.

NVIV-01-06 aims to ensure and maintain an optimal environment for performing the activities, for life care, body integrity and health of workers and other persons taking part in the work process and it establishes the general provisions for the organisation of the activity for verification of ventilation installations operating in environments with potentially explosive and/or toxic atmosphere hazards.

NVIV-01-06 Normative is applied to all companies, whose activity is susceptible to generate potentially explosive and/or toxic atmospheres, in order to ensure the conformity of operational parameters achieved by the ventilation installations with the ones declared by the user.

Ventilation installations under the incidence of NVIV-01-06 Normative are the ones which operate or circulate potentially explosive or toxic atmospheres.

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