Dispersion of Methane in Closed Enclosures

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Abstract

The increase of the population also involve the increase of the consumption of raw materials. This requires the diversification and development of industrial processes in semi-enclosed or open spaces. The carrying out of human activities of an industrial nature involves the accidental use, handling or presence of explosive substances such as methane. The presence of this gas in closed or semi-closed spaces can generate explosion phenomena. The accumulation of methane in narrow spaces is well studied and known, but the dispersion and especially the dispersion dynamics of methane released from a source considered infinite is less known. Knowing how methane disperses into the air is very important for establishing preventive measures. The paper presents the experiment on the dynamics of methane dispersion in a closed enclosure.

Keywords: explosive gas, methane, dispersion, gas dynamics, closed spaces

Introduction

The composition of the atmospheric air varies depending on the place, altitude, period of the year as well as other factors. For the usual calculation up to altitudes of 1500 m it is sufficiently accurate to use the following values: O_2 = 21%; N_2 = 79% - by volume; O_2 = 23%; N_2 = 77% - mass.

Methane is a colorless, tasteless, odorless gas with a molecular weight of 16.0426 g/mol, a density of 0.716 kg/m3 and diffuses 1.6 times faster than air. It also has a melting point of -182 ° C and a boiling point of -161 ° C. Methane gas has a water solubility of 35 mg / l at 17 ° C.

Methane gas is a flammable and explosive gas mixed with air, with an ignition temperature of 595 ° C and an explosive range between 4.4-15% vol. This gas produces a greenhouse effect and is an important element that contributes to the heating global and degrades the ozone layer.

The mixture of methane, ethane and propane also has weak narcotic properties.

Methane burns with a little bright flame. The color of the flame varies, depending on the conditions in which the combustion takes place, from blue, light blue to almost white. At a low gas content in the air, it burns with a dark blue flame, and at higher contents (5% vol.) the flame turns light blue. The methane combustion reaction has the following structure: $CH_4 + 2O_2 = CO_2 + 2H_2O$.

When the combustion of methane is incomplete, namely it occurs under conditions of low oxygen content, the combustion products contain carbon monoxide and hydrogen. In this case, the combustion reaction is:$CH_4 + O_2 = CO + H_2 + H_2O$.

Thus, for a methane content in the air of less than 4.4% vol. CH_4, the mixture is not explosive, but the methane burns in the presence of the ignition source: between 4.4% vol. CH_4 and 15% vol. CH_4, the mixture it is explosive; above 15% vol. CH_4, the mixture is not explosive, but may become explosive by the addition of oxygen.

The national mandatory occupational exposure limit is 1200 mg/m3 or 1834 ppm. for long-term exposure at 8 hours, respectively 1500 mg/m3 or 2292 ppm. for short exposure at 15 min.

Description of the Problem

The presence of pollutants in industrial premises is a major risk that is given priority attention. If there is an unexpected release of methane gas in an enclosed space, then the risk of explosion is imminent [1-3]. The explosion phenomenon can occur if the three elements overlap in time and space: gases, mists, dusts or combustible dusts, atmospheric oxygen and the efficient source of ignition. Methane gas, in addition to its explosive nature, is itself an asphyxiating gas that indoors can lead to a sharp decrease in oxygen concentration but in the case of the explosion phenomenon the dynamic effect is more important, an effect that also occurs in the case of production explosions in semi-closed and open spaces. The topic of gas dispersion has been studied extensively internationally [4-11]. However, in particular, the dispersion dynamics of methane-type explosive gases in closed enclosures has been less studied but can be analyzed mathematically using fluid dynamics or by experiments [12-18]. The specificity of the methane dispersion dynamics in the closed enclosure is generated by the appearance of non-uniform concentrations with large variations both horizontally and vertically. The results of the detailed analysis can be used to determine the escape routes in the event of an unexpected release of methane into the closed industrial premises.

Establishing the Experimentation Conditions

The experimentation regarding the establishment of the dynamics of formation and dispersion of explosive atmospheres was carried out in the industrial ventilation laboratory within INCD INSEMEX Petroșani. The experimental system used consists of a data acquisition equipment and a monitoring system consisting of 6 pulleys to which are attached 6 multi-gas detectors of ALTAIR type, which can detect concentrations of O_2, CO_2, CO and CH_4. The pulley system can config. a variable spatial arrangement in order to determine the rate of gas dispersion as well as the dynamics of the formation of explosive atmospheres. In order to ensure the safety and health conditions at work at the place of experimentation, a complex ventilation system with variable structure is used to study the ventilation capacity of closed enclosures with the risk of forming potentially explosive / toxic / suffocating atmospheres.

Laboratory Experiments

In the experimental laboratory, the dynamics of the formation of the explosive atmosphere using methane, CH4, was analyzed. The measuring instruments used are of the MSA - ALTAIR type and have the following series: Apparatus no. 1: 000 6011 454 MSA; Apparatus No. 2: 000 6010 119 MSA; Apparatus No. 3,000 6011 456 MSA; Apparatus No. 4: 000 6011 457 MSA; Apparatus No. 5: 000 6010 120 MSA; Apparatus No. 6: 000 6011 455 MSA. The ground section of the experimental enclosure is 5.8x5.62 m. The height of the enclosure is 3.65 m. Consequently, the total volume of the experimental enclosure is 118.9754 m3. Considering the fact that other experimental systems are located in the enclosure, the free volume of the enclosure is 116 m^3.

For the analysis of the dynamics of the formation of the explosive atmosphere was used "the experimental system for the study of the dynamics of the formation of potentially explosive / toxic / asphyxiating atmospheres".

The initial test conditions were as follows: Temperature: T = 29.9 ° C; Atmospheric pressure: B = 9,440 daPa; Relative humidity: RH = 40.5%; Discharge gas flow: q = 4.5 l/min.

Fig. 1. Introduction gas system into the enclosure

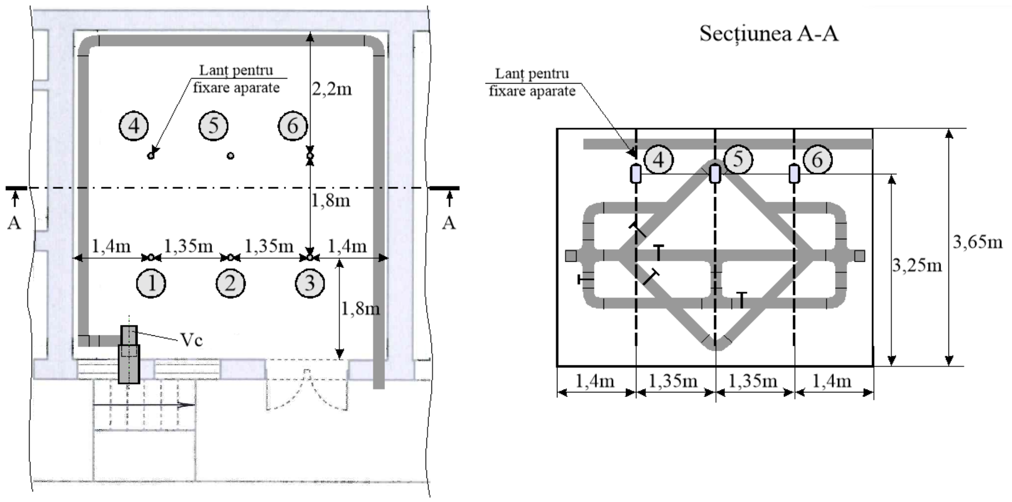

Fig. 2. Location of the detection system

The gas introduction system in the enclosure is shown in Fig. 1. The system consists of a bottle of methane gas compressed to a pressure of 200 bar at a concentration of 100% Vol., A pressure reducer and a float flow meter. The gas was introduced into the enclosure by means of a hose with an inner diameter of 8 mm. The methane gas was discharged inside the enclosure by means of a support located at 0.25 m from the floor on the eastern wall at the middle of its base side. The hose was fixed in a horizontal position in the E-V direction.

The MSA - ALTAIR detection devices were positioned on the 6 pulleys at the ceiling level and the height at which the suction and detection area of the devices was positioned was 3.25 m of the floor, Fig. 2.

As a result of the experiment, the following results were obtained in tables 1-6:

Tab. 1. At the level of the MSA ALTAIR device no. 1.

Data **Altair 5X -1**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:25:30 PM	0	20.8	20.8	0	0	0.03	31
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8/6/2020 1:34:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:37:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:40:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:43:30 PM	0,1	20.8	20.8	0	0	0.03	30
8/6/2020 1:46:30 PM	0,2	20.8	20.8	0	0	0.03	30
8/6/2020 1:49:30 PM	0,25	20.8	20.8	0	0	0.03	29
8/6/2020 1:52:30 PM	0,25	20.8	20.8	0	0	0.03	29
8/6/2020 1:55:30 PM	0,3	20.8	20.8	0	0	0.03	29
8/6/2020 1:58:30 PM	0,35	20.8	20.8	0	0	0.03	29
8/6/2020 2:01:30 PM	0,3	20.8	20.8	0	0	0.03	29
8/6/2020 2:04:30 PM	0,35	20.8	20.8	0	0	0.03	29
8/6/2020 2:07:30 PM	0,35	20.8	20.8	0	0	0.03	29
8/6/2020 2:10:30 PM	0,35	20.8	20.8	0	0	0.03	29
8/6/2020 2:13:30 PM	0,4	20.8	20.8	0	0	0.03	29
8/6/2020 2:16:30 PM	0,45	20.8	20.8	0	0	0.03	29
8/6/2020 2:19:30 PM	0,4	20.8	20.8	0	0	0.03	29
8/6/2020 2:22:30 PM	0,5	20.8	20.8	0	0	0.03	29
8/6/2020 2:25:30 PM	0,5	20.8	20.8	0	0	0.03	29
8/6/2020 2:28:30 PM	0,5	20.8	20.8	0	0	0.03	29
8/6/2020 2:31:30 PM	0,5	20.8	20.8	1	0	0.03	29
8/6/2020 2:34:30 PM	0,55	20.8	20.8	0	0	0.03	30
8/6/2020 2:37:30 PM	0,55	20.8	20.8	0	0	0.03	30
8/6/2020 2:40:30 PM	0,6	20.8	20.8	0	0	0.03	30
8/6/2020 2:43:30 PM	0,6	20.8	20.8	0	0	0.03	30
8/6/2020 2:46:30 PM	0.6	20.8	20.8	1	0	0.03	30
8/6/2020 2:49:30 PM	0.6	20.8	20.8	0	0	0.03	30
8/6/2020 2:52:30 PM	0.6	20.8	20.8	0	0	0.03	30
8/6/2020 2:55:30 PM	0,65	20.8	20.8	0	0	0.03	30
8/6/2020 2:58:30 PM	0,7	20.8	20.8	0	0	0.03	30

Tab. 2. At the level of the MSA ALTAIR device no. 2.

Data **Altair 5X -2**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:26:00 PM	0	20.8	20.8	0	0	0.03	33
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8/6/2020 1:44:00 PM	0	20.8	20.8	0	0	0.03	33
8/6/2020 1:47:00 PM	0	20.8	20.8	0	0	0.03	33
8/6/2020 1:50:00 PM	0	20.8	20.8	0	0	0.03	32
8/6/2020 1:53:00 PM	0	20.8	20.8	0	0	0.03	32
8/6/2020 1:56:00 PM	0,2	20.8	20.8	1	0	0.03	32
8/6/2020 1:59:00 PM	0,2	20.8	20.8	1	0	0.03	32
8/6/2020 2:02:00 PM	0,2	20.8	20.8	0	0	0.03	32
8/6/2020 2:05:00 PM	0,2	20.8	20.8	0	0	0.03	32
8/6/2020 2:08:00 PM	0,2	20.8	20.8	0	0	0.03	32
8/6/2020 2:11:00 PM	0,2	20.8	20.8	0	0	0.03	32
8/6/2020 2:14:00 PM	0,2	20.8	20.8	0	0	0.03	32
8/6/2020 2:17:00 PM	0,25	20.8	20.8	0	0	0.03	32
8/6/2020 2:20:00 PM	0,25	20.8	20.8	1	0	0.03	32
8/6/2020 2:23:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:26:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:29:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:32:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:35:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:38:00 PM	0,3	20.8	20.8	0	0	0.03	32
8/6/2020 2:41:00 PM	0,35	20.8	20.8	0	0	0.03	32
8/6/2020 2:44:00 PM	0,35	20.8	20.8	0	0	0.03	32
8/6/2020 2:47:00 PM	0,35	20.8	20.8	0	0	0.03	32
8/6/2020 2:50:00 PM	0,4	20.8	20.8	0	0	0.03	32

Tab. 3. At the level of the MSA ALTAIR device no. 3.

Data **Altair 5X -3**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:28:30 PM	0	20.8	20.8	1	0	0.03	31
………………………..	………..	………..	………..	…………	…………	……………	………..
8/6/2020 1:58:30 PM	0	20.8	20.8	1	0	0.03	30
8/6/2020 2:01:30 PM	0	20.8	20.8	1	0	0.03	30
8/6/2020 2:04:30 PM	0	20.8	20.8	1	0	0.03	30
8/6/2020 2:07:30 PM	0	20.8	20.8	1	0	0.03	30
8/6/2020 2:10:30 PM	0,2	20.8	20.8	1	0	0.03	30
8/6/2020 2:13:30 PM	0,2	20.8	20.8	1	0	0.03	30
8/6/2020 2:16:30 PM	0,2	20.8	20.8	1	0	0.03	30
8/6/2020 2:19:30 PM	0,2	20.8	20.8	1	0	0.03	30
8/6/2020 2:22:30 PM	0,25	20.8	20.8	1	0	0.03	30
8/6/2020 2:25:30 PM	0,25	20.8	20.8	1	0	0.03	30
8/6/2020 2:28:30 PM	0,3	20.8	20.8	1	0	0.03	30
8/6/2020 2:31:30 PM	0,3	20.8	20.8	1	0	0.03	30
8/6/2020 2:34:30 PM	0,3	20.8	20.8	1	0	0.03	30
8/6/2020 2:37:30 PM	0,35	20.8	20.8	1	0	0.03	30
8/6/2020 2:40:30 PM	0,35	20.8	20.8	2	0	0.03	30
8/6/2020 2:43:30 PM	0,35	20.8	20.8	1	0	0.03	30
8/6/2020 2:46:30 PM	0,35	20.8	20.8	1	0	0.03	30
8/6/2020 2:49:30 PM	0,35	20.8	20.8	1	0	0.03	30
8/6/2020 2:52:30 PM	0,35	20.8	20.8	1	0	0.03	30
8/6/2020 2:55:30 PM	0,4	20.8	20.8	1	0	0.03	30

Tab. 4. At the level of the MSA ALTAIR device no. 4.

Data **Altair 5X -4**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:25:30 PM	0	20.8	20.8	1	0	0.03	31
…………………………	…………..	…………	………….	………….	…………	……………	…………
8/6/2020 1:40:30 PM	0	20.8	20.8	0	0	0.03	31
8/6/2020 1:43:30 PM	0	20.8	20.8	0	0	0.03	31
8/6/2020 1:46:30 PM	0	20.8	20.8	0	0	0.03	31
8/6/2020 1:49:30 PM	0	20.8	20.8	0	0	0.03	31
8/6/2020 1:52:30 PM	0,2	20.8	20.8	0	0	0.03	31
8/6/2020 1:55:30 PM	0,25	20.8	20.8	1	0	0.03	31
Data **Altair 5X -4**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:58:30 PM	0,25	20.8	20.8	0	1	0.03	31
8/6/2020 2:01:30 PM	0,25	20.8	20.8	0	0	0.03	31
8/6/2020 2:04:30 PM	0,25	20.8	20.8	0	0	0.03	30
8/6/2020 2:07:30 PM	0,25	20.8	20.8	0	0	0.03	30
8/6/2020 2:10:30 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 2:13:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:16:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:19:30 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 2:22:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:25:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:28:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:31:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:34:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:37:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:40:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:43:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:46:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:49:30 PM	0,5	20.8	20.8	0	0	0.03	31
8/6/2020 2:52:30 PM	0,55	20.8	20.8	0	0	0.03	31

Tab. 5. At the level of the MSA ALTAIR device no. 5.

Data **Altair 5X -5**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:26:15 PM	0	20.8	20.8	0	0	0.03	31
....	....	....	....	....	....	....	....
8/6/2020 1:35:15 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:38:15 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:41:15 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 1:44:15 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 1:47:15 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 1:50:15 PM	0,55	20.8	20.8	0	0	0.03	30
8/6/2020 1:53:15 PM	0,55	20.8	20.8	0	0	0.03	30
8/6/2020 1:56:15 PM	0,6	20.8	20.8	0	0	0.03	30
8/6/2020 1:59:15 PM	0,65	20.8	20.8	0	0	0.03	30
Data **Altair 5X -5**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 2:02:15 PM	0,7	20.8	20.8	0	0	0.03	30
8/6/2020 2:05:15 PM	0,7	20.8	20.8	0	0	0.03	30
8/6/2020 2:08:15 PM	0,7	20.8	20.8	0	0	0.03	30
8/6/2020 2:11:15 PM	0,7	20.8	20.8	0	0	0.03	30
8/6/2020 2:14:15 PM	0,75	20.8	20.8	0	0	0.03	30
8/6/2020 2:17:15 PM	0,8	20.8	20.8	0	0	0.03	30
8/6/2020 2:20:15 PM	0,85	20.8	20.8	0	0	0.03	31
8/6/2020 2:23:15 PM	0,85	20.8	20.8	0	0	0.03	31
8/6/2020 2:26:15 PM	0,85	20.8	20.8	0	0	0.03	31
8/6/2020 2:29:15 PM	0,85	20.8	20.8	0	0	0.03	31
8/6/2020 2:32:15 PM	0,85	20.8	20.8	0	0	0.03	31
8/6/2020 2:35:15 PM	0,95	20.8	20.8	0	0	0.03	31
8/6/2020 2:38:15 PM	0,95	20.8	20.8	0	0	0.03	31
8/6/2020 2:41:15 PM	1,0	20.8	20.8	0	0	0.03	31
8/6/2020 2:44:15 PM	1,0	20.8	20.8	0	0	0.03	31
8/6/2020 2:47:15 PM	1,05	20.8	20.8	0	0	0.03	31
8/6/2020 2:50:15 PM	1,05	20.8	20.8	0	0	0.03	31
8/6/2020 2:53:15 PM	1,1	20.8	20.8	0	0	0.03	31
8/6/2020 2:56:15 PM	1,15	20.8	20.8	0	0	0.03	31

Tab. 6. At the level of the MSA ALTAIR device no. 6.

Data **Altair 5X -6**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 1:26:30 PM	0	20.8	20.8	0	0	0.03	31
…………………………..	…………..	………..	…………..	…………	………….	…………..	………….
8/6/2020 1:38:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:41:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:44:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:47:30 PM	0	20.8	20.8	0	0	0.03	30
8/6/2020 1:50:30 PM	0,2	20.8	20.8	0	0	0.03	30
8/6/2020 1:53:30 PM	0,25	20.8	20.8	0	0	0.03	30
8/6/2020 1:56:30 PM	0,25	20.8	20.8	1	0	0.03	30
8/6/2020 1:59:30 PM	0,25	20.8	20.8	0	0	0.03	30
8/6/2020 2:02:30 PM	0,25	20.8	20.8	0	0	0.03	30
Data **Altair 5X -6**	COMB(1)	O2(2)		CO(3)	H2S(4)	CO2(6)	°C
	Peak	Min	Max	Peak	Peak	Peak	
8/6/2020 2:05:30 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 2:08:30 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 2:11:30 PM	0,3	20.8	20.8	0	0	0.03	30
8/6/2020 2:14:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:17:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:20:30 PM	0,35	20.8	20.8	0	0	0.03	30
8/6/2020 2:23:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:26:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:29:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:32:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:35:30 PM	0,4	20.8	20.8	0	0	0.03	30
8/6/2020 2:38:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:41:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:44:30 PM	0,45	20.8	20.8	0	0	0.03	30
8/6/2020 2:47:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:50:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:53:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:56:30 PM	0,5	20.8	20.8	0	0	0.03	30
8/6/2020 2:59:30 PM	0,55	20.8	20.8	0	0	0.03	30

The duration of the experiment was 120 min. The volume of methane gas introduced into the enclosure was 418.5 liters or 0.4185 m3.

The dynamics of methane gas dispersion at the closed enclosure is shown graphically in Fig. 3.

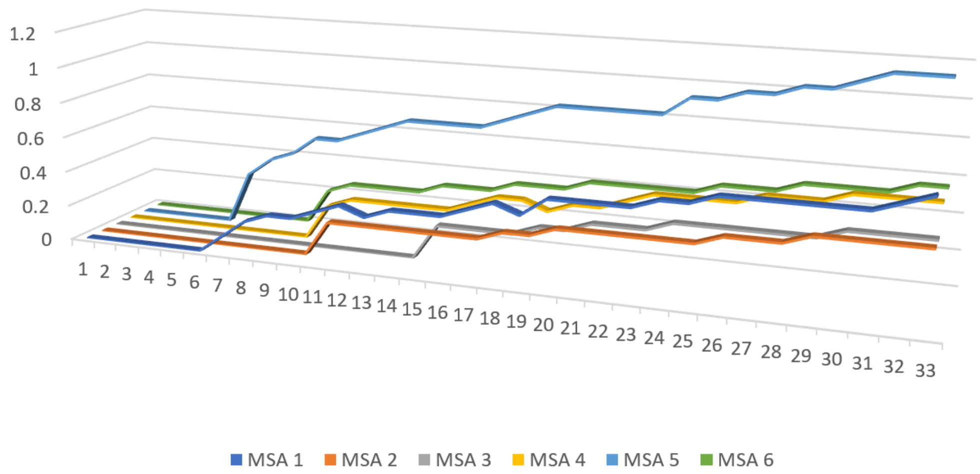

Fig. 3. Dynamics of methane gas dispersion in closed enclosure

Discussions

From the experiment on the dispersion of explosive gases in closed enclosure using methane CH4, the following discussions emerge:

- The process of dispersing methane gas indoors has had 2 distinct stages, namely:
- The incubation period in which the gas is dispersed and diluted without reaching a detectab. concentration in the MSA ALTAIR measuring devices;
- The accumulation period in which the gas is dispersed and reaches progressively increasing concentrations at the level of MSA ALTAIR meters;
- The dispersion process is characterized by a variable evolution both horizontally and vertically. This aspect is proved by the different values of the gas concentrations at the level of the detection devices, in the same time interval;
- The incubation period showed different values depending on the position in the plane of the detection devices as follows:
- The incubation period was reduced at the level of the detection devices located in points 1 and 5 being of 15 respectively 18 min .;
- The incubation period was average at the level of the detection devices located in points 2, 4 and 6 being 24; 27 respectively 30 min .;
- The incubation period was long at the level of the detection device located in point 3 being 42 min .;
- The accumulation period showed different evolutions depending on the position in the plan of the detection devices as follows:
- The accumulation period was reduced at the level of the detection devices located in points 2 and 3 being of 46.5 respectively 53 min .;
- The accumulation period was average at the level of the detection device located in point 4 being 61.5 min.;
- The accumulation period was long at the level of the detection devices located in points 1, 5 and 6 being 73.5; 73.25 and 68.5 min, respectively;
- The period of dispersion and progressive dilution of the gas comprising the incubation and accumulation segments showed different developments depending on the position in the plane of the detection devices as follows:
- The period of dispersion and progressive dilution of the gas was reduced to the level of the detection apparatus located in point 2 being 84 min .;
- The period of dispersion and progressive dilution of the gas was average at the level of the detection devices located in points 3, 4 being 87 min;
- The period of dispersion and progressive dilution of the gas was long at the level of the detection devices located in points 1;5 and 6 being of 93; 90 and 93 min. respectively;
- The maximum gas concentration showed different evolutions depending on the position in the plane of the detection devices as follows:
- The maximum gas concentration of the gas was reduced at the level of the detection devices located in points 2 and 3 being 0.4 and 0.4 % Vol .;
- The maximum gas concentration was average at the level of the detection devices located in points 1, 4 and 6 being 0.7; 0.55 and 0.55 % vol .;
- The maximum gas concentration of the gas was high at the level of the detection device located in point 5 being 1.15 % Vol .;
- The gradient of dispersion and progressive dilution of the gas at the level of the closed enclosure, Gd, showed a variable evolution depending on the position in the plane of the detection devices as follows:
- The gradient of dispersion and progressive dilution of the gas at the enclosure level, Gd, showed reduced values at the level of the detection devices located in points 2 and 3 being of 0.286 respectively 0.276 % Vol. / h;
- The gradient of dispersion and progressive dilution of the gas at the enclosure level, Gd, presented average values at the level of the detection devices located in points 4 and 6 being of 0.379 respectively 0.355 % Vol. / h;
- The gradient of dispersion and progressive dilution of the gas at the enclosure level, Gd, showed a high value at the level of the detection device located in point 1 being 0.452 % Vol. / h;
- The gradient of dispersion and progressive dilution of the gas at the enclosure level, Gd, presented a very high value at the level of the detection device located in point 5 being of 0.767 % Vol. / h;

The methane gas discharged in the closed enclosure showed a phenomenon of uneven accumulation at the ceiling level proved by the fact that gas concentrations were identified, at the level of detection devices, between 0.4-1.15% Vol. Compared to the value of the average concentration in relation to the total volume of the closed enclosure of 0.36% Vol.

Conclusions

For the study of the dynamics of formation of toxic, asphyxiating or explosive atmospheres, in the experimental laboratory for the study of industrial ventilation systems, the following experiments were performed on the dynamics of explosive atmosphere formation using methane, CH4;

The process of dispersing methane gas indoors presented 2 distinct stages, namely: the incubation period and the accumulation period;

The methane dispersion process is characterized by a variable evolution both horizontally and vertically. This aspect is proved by the different values of the gas concentrations at the level of the detection devices, in the same time interval;

The incubation period showed values between 18 and 42 minutes;

The accumulation period showed evolutions between 46.5 and 73.5 minutes;

The period of dispersion and progressive dilution of the gas comprising the incubation and accumulation segments showed evolutions between 84 and 93 minutes;

The maximum concentration of methane gas showed a variable evolution with values between 0.4 and 1.15 % Vol .;

The gradient of dispersion and progressive dilution of methane gas at the closed enclosure, Gd, showed a variable evolution being between 0.286 - 0.767 % Vol. / h;

The methane gas discharged indoors showed a phenomenon of uneven accumulation at the ceiling level proved by the fact that gas concentrations were identified at the level of detection devices, between 0.4 - 1.15 % Vol. Compared to the value of the average concentration in relation to the total volume of the enclosure of 0.36 % Vol.;

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