Assessment of Explosion Risks in the Presence of Hydrocarbon Mixtures

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Introduction

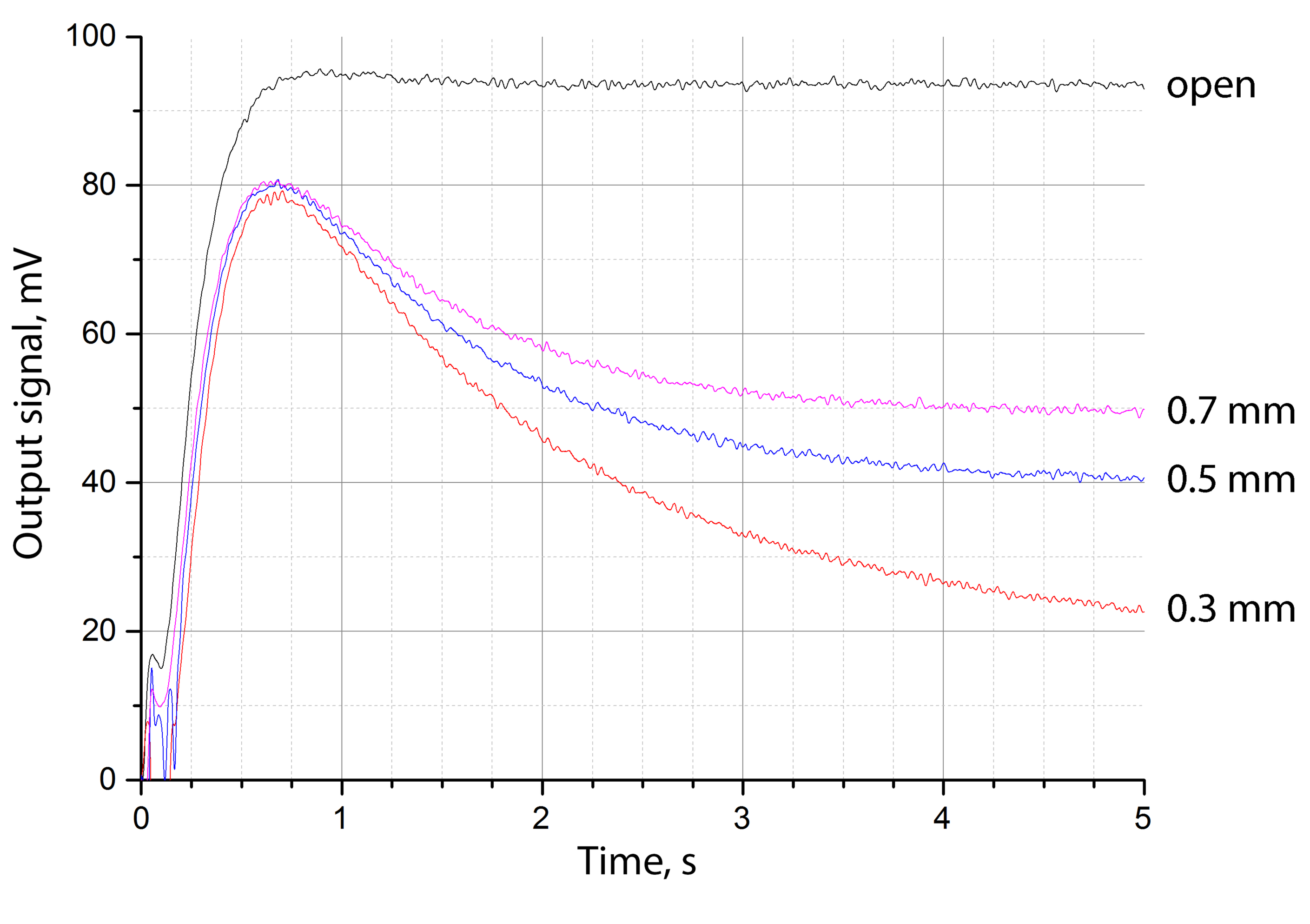
The most of gas associated industries face with the risks of explosion and fire which may lead to dire consequences. We present an approach for assessing the explosion risks in the presence of hydrocarbon mixtures when the chemical composition and concentration of gases in the mixture are unknown. The core idea is the measurement of warm dissipated during the combustion of hydrocarbons in the reaction chamber of the sensor. To evaluate this approach we use a catalytic planar sensor with limited gas diaphragm in the reaction chamber. We demonstrate the feasibility of our approach experimentally.

Approach

The cornerstone of the approach is the phenomena of combustion gas heat multiplied by %LEL. The resultant value is rather equal for most gases (9.5±15% max.).
For calculating the amount of emitted warm on the sensor it is essential to limit the gas diffusion to the sensor reaction chamber for ensuring the burn of fixed gas volume. For effectuating this task we use the catalytic sensor DTK-3 by NTC-IGD with a small hole diaphragm in the sealed cap to control the speed of gas flow into the reaction chamber. The diaphragm diameter is defined empirically. This speed must be much higher than the speed of gas burning in the package. According to industrial standards the speed of chamber filling must be less than the sensor response time to gas detection in the atmosphere.

Widely used hydrocarbons in Oil and Gas producing industry

Gas	Concentration C_{LEL}, %vol.	Standard combustion heat Q^0, kcal/mole	$C_{LEL} \cdot Q^0$, kcal/mole
Methane CH_4	4,4	191,554	8,428
Ethane C_2H_6	2,5	376,421	9,411
Propane C_3H_8	1,7	488,201	8,299
Benzol C_6H_6	1,2	756,998	9,084
Toluol C_7H_8	1,1	900,898	9,910
Cyclohexane C_6H_{12}	1,2	881,103	10,573
Methyl alcohol CH_4O	5,5	182,43	10,034
Acetone C_3H_6O	2,5	435,029	10,876

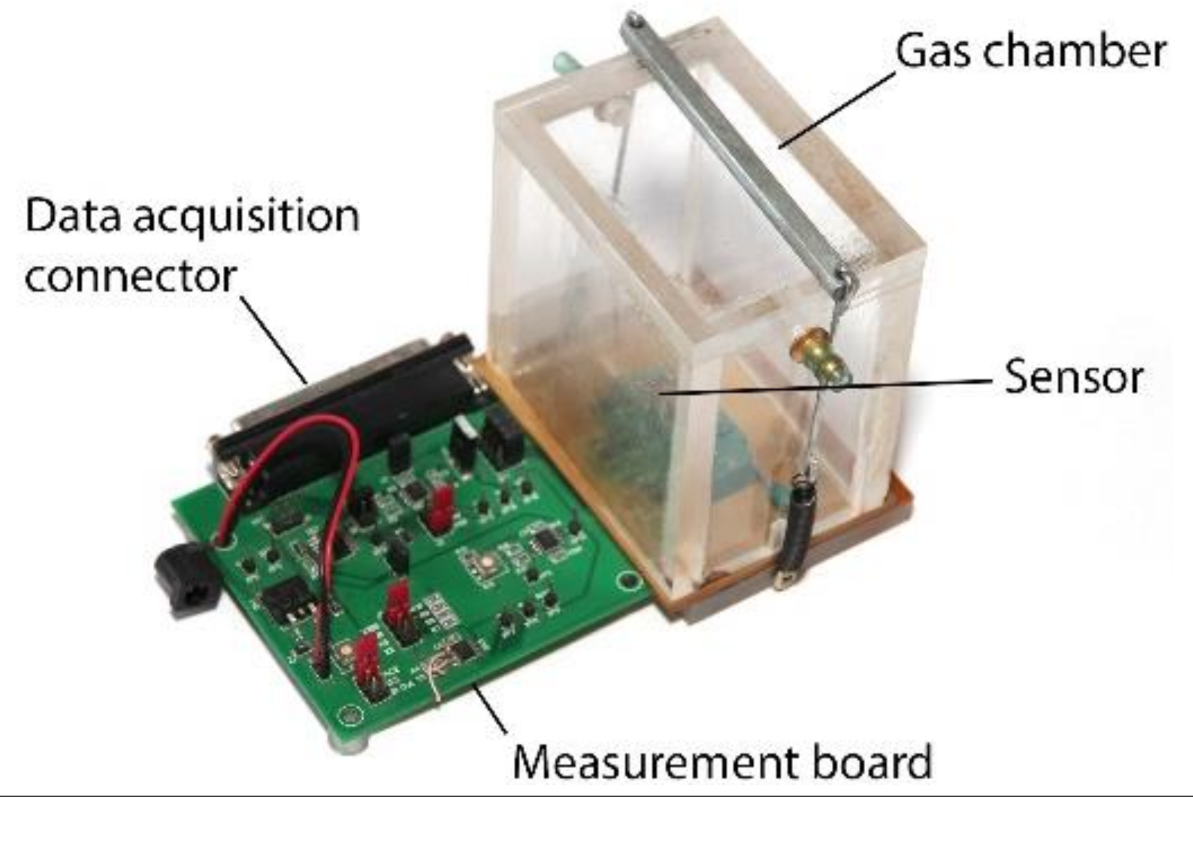


Gas burning and resultant response signal w.r.t. hole diameter

Advantages

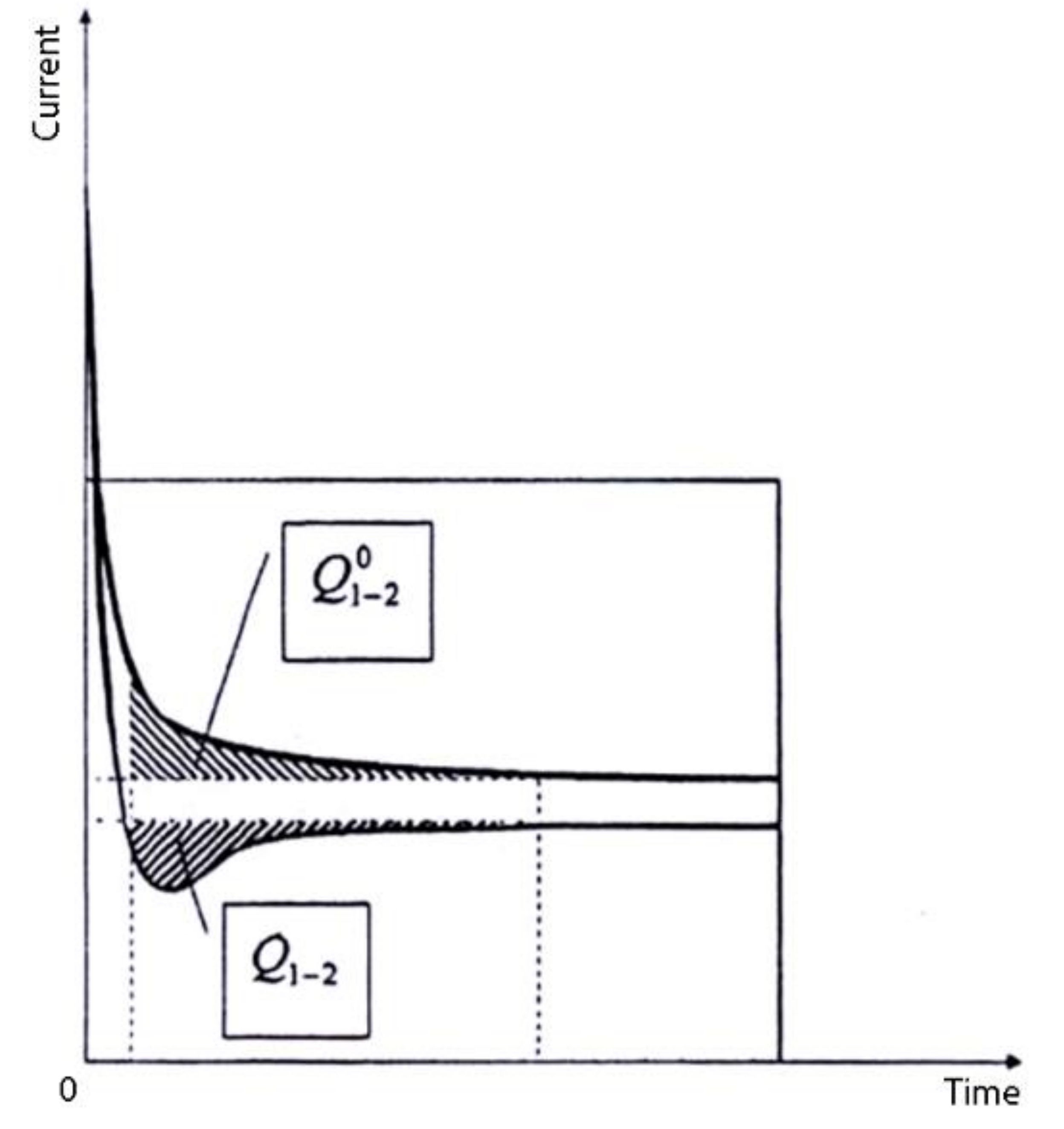
- Just one gas sensor is required;
- Low power consumption;

Testbed

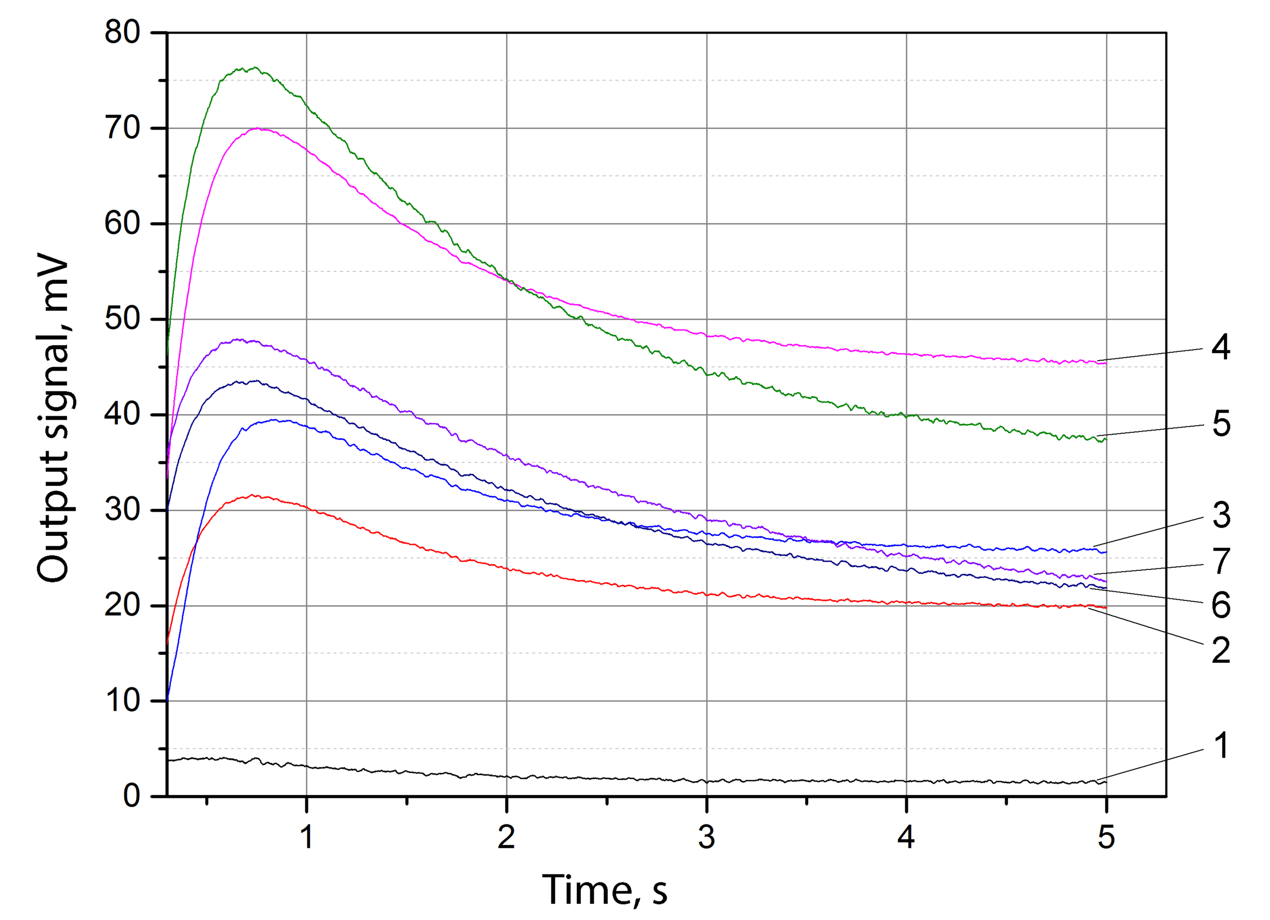


Experimental results

We put the sensor in the atmosphere without gases and measure the amount of warm $Q^0_{1\text{-}2}$ emitted on the catalytic element during the measurement procedure in the time interval τ_1 - τ_2. We conduct the same experiment to measure the amount of warm $Q_{1\text{-}2}$ in the presence of gas in the same time interval.



Current variation at gas burning process in the sensor package



Transition state for typical hydrocarbons '1' – 0,1% CH_4; '2' – 1% CH_4; '3' – 1,4% CH_4; '4' – 2,5% CH_4, '5' – 1% C_3H_8; '6' – 0,6% C_4H_{10}; '7' – 0,5% C_6H_{14}.

Total explosiveness of three gas mixtures

Mixture composition		Mixture concentration		Formula LEL, % vol	Mixture concentration LEL, % vol (% LEL)	Measured LEL, % vol
Gas 1	Gas 2	Gas 1	Gas 2			
H_2 0.96%vol	CH_4 1.47%vol	H_2 0.384%vol	CH_4 0.882%vol	4.270 CH_4+H_2	1.266 (30)	32
CH_4 1.47%vol	C_3H_8 1.01%vol	CH_4 0.882%vol	C_3H_8 0.404%vol	2.935 CH_4+C_3H_8	1.286 (44)	44
CH_4 1.47%vol	C_4H_{10} 1.01%vol	CH_4 1.187%vol	C_4H_{10} 0.128%vol	3.641 CH_4+C_4H_{10}	1.315 (36)	38

Experimental conditions

- Gas mixtures are flown through measurement chamber using the inlet valves;
- The valves set constant gas flow through the chamber;
- As a result, there is a stable gas mixture and air concentration in the chamber.

Conclusions

1. We have proposed and experimentally evaluated the approach for the assessment of explosion risks in the presence of hydrocarbon mixtures when the concentrations of gases in the mixture are unknown.

2. The approach is based upon the measurement of warm dissipated during the combustion of hydrocarbons in the reaction chamber of the catalytic sensor.

3. The experimental results on the assessment of the total explosiveness of gas mixtures are in agreement with the calculated values (% vol.). The experiments are conducted for the mixtures of different hydrocarbons and the mixture of H_2 and CH_4.

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