INFLUENCE OF ATMOSPHERIC STABILITY ON PROPAGATION OF ETHYLENE, DISCHARGED THROUGH A VENT STACK IN THE AMBIENT ENVIRONMENT

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Abstract. *Numerical modeling of discharge of ethylene through a vent stack under various atmospheric stabilities is carried out. Indicative common factors of propagation of ethylene with the account of meteorological conditions are determined. A conclusion is made regarding a necessity of conducting a thorough analysis of discharges of this kind.*

Key words: *discharge through a stack; hazardous gas; numerical modeling; meteorological conditions.*

In cases of emptying the equipment during repair shutdowns or emergencies, it is necessary to free the equipment from circulating gases using vent stacks (vertical pipes for discharging wastes). Discharges of hazardous gases from a stack must be safe: the formed air-gas clouds should not reach the residential areas and industrial sites filled with processing equipment. However, in practice under certain meteorological conditions a distribution of dangerous concentration of the air-gas mixtures can take place directly within industrial sites and residential areas [1].

For determining the influence of the atmospheric conditions on discharge of ethylene, numerical modeling with the use of a model and a method described in articles [2-3] was carried out. The same types of discharges of ethylene at various atmospheric stratification conditions (stable, neutral and unstable) were calculated. Calculations were conducted at a subcritical speed of efflux of ethylene with the following set parameters at the stack's tip: gauge pressure is 0.1 MPa s, temperature is 315 K. The stack had the following dimensions: height is 10 m, diameter is 0.1 m. Wind speed at the height of 10 m was taken as equal to 1 m/s, roughness of the underlying terrain was considered as equal to 0.01 m, and its temperature was 303.15 K. In the calculations, the Monin-Obukhov length scale for stable, neutral and unstable stratifications was 309.5 m, 0 m and -108.1 m, respectively. The structured grid with cells refined near the ground, the mouth and the source's barrel was used. For saving computational time and reducing demands for computing resources, a symmetric problem with a symmetry axis coinciding with the discharge axis from the stack was considered, i.e. calculation of only a half of the working domain was actually made. Results of calculations are given in Fig. 1. Values of concentration at various heights from a terrestrial surface (in vol. %) on the axis of ordinates for convenience of presenting the information (the considered range of values is very broad) were shown using the logarithmic scale.

Results of calculations have brought us to an interesting conclusion that near the stack (at distances from the stack up to 100 m), values of concentration at unstable and neutral stratifications of the atmosphere are even greater than those present at the stable stratification case. It can be explained by the fact that ethylene is a light gas capable of intensively mixing up with air under conditions of increased turbulization of the atmosphere (values of turbulent characteristics at the unstable atmosphere exceed the ones at the stable atmosphere). Owing to this, already at an early stage of discharge, rather large amounts of ethylene reach the terrestrial surface. In case of stable stratification (inversion), gas leans to the terrestrial surface smoothly; only at certain distances from the stack (> 100 m) values of concentration become much greater than those during discharges under the influence of other types of atmospheric stratification. It should be noted that even at the subcritical efflux of the gas from the stack, similar discharges of ethylene are not safe, since already at the distance 12.5 m from the stack, concentration of ethylene starts exceeding considerably the maximum admissible concentration value.

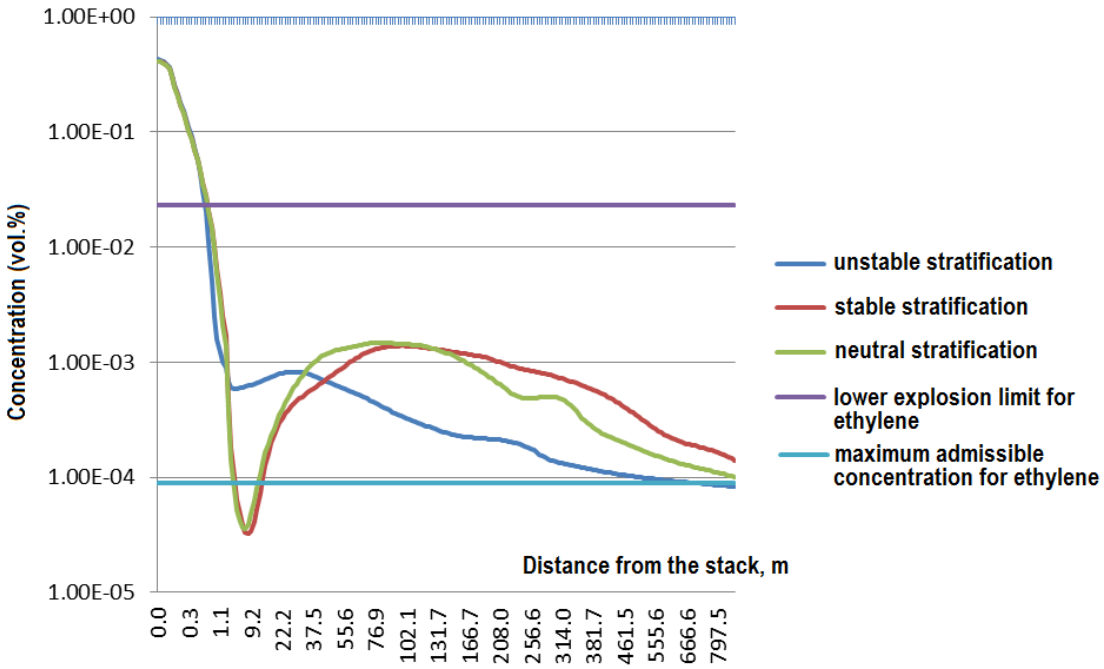

Fig. 1 – Dependence of concentration on atmospheric stratification away from the stack (height above the ground, over which the concentrations are determined, is 10 m).

Therefore, for improving the safety of operation and designs of the stacks, the comprehensive analysis of propagation of ethylene released from a stack must be carried out together with studying the influence of atmospheric stability on this process.

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