Applied problems of information systems operation

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A. Roianov, S. Garbuz

National University of Civil Defence of Ukraine, Kharkiv, Ukraine

THE ASSESSEMENT OF THE SCALES AND THE RISK OF THE APPEARANCE TECHNOGENOUS SITUATIONS DURING THE PROCESS OF DEGASING THE STORAGE TANKS OF LIGHT PETROLEUM PRODUCTS

The subject of study in this article is the processes of increasing the level of the environmental and fire safety during the degassing of the vertical cylindrical tanks with the remaints of the light petroleum products. **The purpose of this work** is concluded in controlling the level of the environmental and fire safety of the territories in the zone of the influence the oil saving objective complexes using the application of the method proposed by U.S. Environmental Protection Agency. The Office of Emergency Management Center, EPA, developed the ALOHA® software product that is used to calculate the distribution of the concentrations during the evaporation of pollutants due to their getting into the oil processing station under different conditions. The task is to assess the level of anthropogenic pressure on the environment, and the influence oil product vapors by the forced decontamination of light oil storage tanks. **The methods** used here are researching conducted with the use of gas analysis to establish the qualitative and quantitative composition of the gas mixtures at the outlet of the tanks, using the modern test equipment. **The following results** have been obtained. Due to the researching, the methodology for calculating and forecasting the level of the technogenic load on the atmospheric air by modeling and forecasting the zones of the active pollution by emissions of the vapor-air hydrocarbon mixtures has been developed further. **The conclusions**. On the basis of the conducted studies, an active contamination zone was determined when performing forced degassing with the air supply, which was carried out using the traditional method, using software for modeling dispersion of pollutants. It has been established that by the forced ventilation of RVS-5000 reservoir, 1.5 tons of the vapor-air mixture get into the natural environment. Using the ALOHA® software product, the hazardous area was estimated, and the area of possible explosion of the gasoline vapors during the natural degassing of the tanks with the storage of light oil products. The size of the zone of the strong toxic influences on the population reaches 1.2 km, it was calculated for the given initial conditions, the zone of the fire danger is 80 m, the explosion zone does not exceed 13 m.

Keywords: a forced ventilation; an evaporation rate; a tank cleaning; the environmental pollution; a risk of the explosion.

Introduction

The formulation of the problem. The security problems of the objects of the oil and gas complex are paid a special attention at all levels of legislative and executive power, while one of the most urgent issues remains to ensure protection of the people and territories from the influence of the dangerous factors that may arise in the event of regular operation, emergency situations and during regulatory work on the oil and petroleum products stores.

The most dangerous sources of technogenic loading on the environment are storage tanks of petroleum products as the objects of uncontrolled emissions or steam-air mixtures or steam-gas mixtures and strains of petroleum products with the subsequent occurrence of fires and explosions. According to its physical and chemical properties, light petroleum products are more lethal and explosive and fire hazard, which cause the fire danger of the reservoir parks for storage of this group of hydrocarbons.

The analysis of the recent researches and publications. According to the statistics, [1] that more than 20% of all hazardous emergencies in these facilities are due to violations of the regulatory requirements for regulatory work. The periodicity of the execution of the cleaning the oil storage tanks is specified in the requirements of the normative documents, and on each particular enterprise is supported by the internal regulations. The purification of petroleum product tanks is carried out in the following stages: degassing by ventilation; pumping out of fuel residues; removal of hatches and hinged equipment; cleaning of reservoirs and removal of bottom sediments; diagnostics with replacement (if it is necessary) of joints and gaskets; detailed careful review of containers; drawing up an act of the performed work.

In Fig. 1 it is shown that most part of these stages are associated with potential environmental hazards.

One of the most complex and fire-hazardous technological operations in the process of exploitation of the reservoirs is the preparation of the tanks with residues of petroleum products for fire repair work [2].

The main reasons for the failure of steel tanks are [3]:

- corrosion of the tank body;
- change in pressure (increase or decrease) in the gas space of the reservoir above the permissible norms;
- the tendency of the main body material of the tank boiled (made) from the boiling steel to a fragile destruction in the conditions of a sharp drop in the air temperature or the stored product, especially during periods of negative temperatures and strong winds;
- uneven precipitation of the reservoirs during the process of the exploitation (working), especially in the areas with the unstable soils;

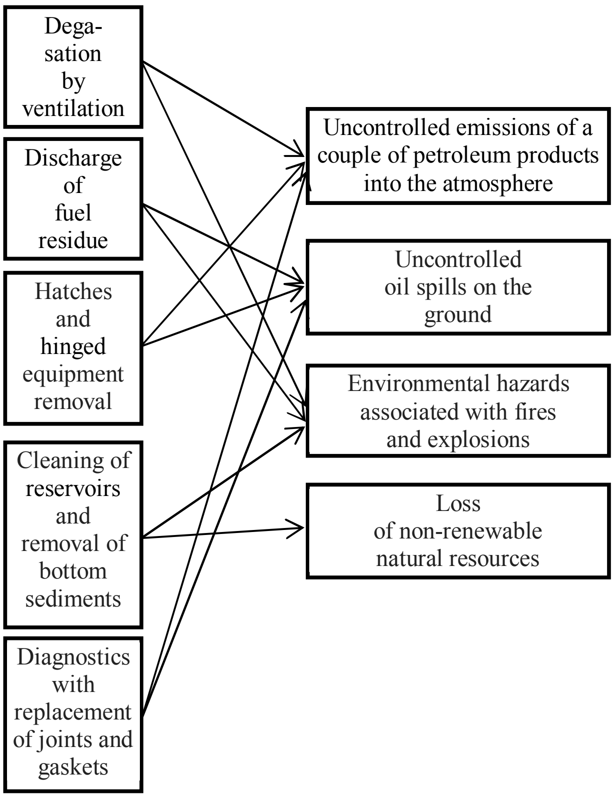

Fig. 1. Stages of the reservoir preparation for carrying out of the scheduled work and their ecological danger

- formation of stresses, especially dangerous in the lower belt of the reservoirs when combined with walls of the reservoir bottom.

Therefore, every year the number of accidents on the tanks is increasing rapidly. The main reason for this tendency is the exhaustion of the main exploitation resource for the most tanks. The wear of used vertical steel tanks according to [4] is 60-80%. An analytical review of the state of the man-made and natural safety in Ukraine, in particular the fire one, for 2013-2017 years.

Setting the task and its solution

The normative document [5] proposed a method for calculating the size of the distribution zones of the cloud of combustible vapors in the case of the accident. It is assumed that the resulting concentration of the gas in the steam-air cloud is calculated by the formula:

$$C_{(x,y,z)}=\sum_{j=1}^{n}\frac{2Q_j}{(2\pi)^{1,5}\cdot\sigma_{yj}^2\cdot\sigma_{zj}}\cdot\exp\left(-\frac{(x-x_j)^2}{2\cdot\sigma_{yj}^2}\right)\times$$
$$\times\exp\left(-y^2/\left(2\cdot\sigma_{yj}^2\right)\right)\cdot\exp\left(-z^2/\left(2\cdot\sigma_{zj}^2\right)\right), \quad (1)$$

where $Q=m-\tau_j$ – is the mass of the liquefied hydro-carbon gases (LHG) in j elemental volume, kg; m - is the mass rate of the leakage of LHG, kg / s; σ_{yj} , σ_{zj} - the average square deviation of the distribution of the concentrations in the j-th elemental volume, m, $\sigma_y\cdot(x_c-x_o);\sigma_z\cdot(x_c-x_o)$ – depends on Pascville's resistance class.

When $x_c=x_o$ accepted

$$\sigma_{y0}=\frac{r}{2,14},\ \sigma_{z0}=\frac{h}{2,14}.$$

When $x_c>x_o$ accepted

$$\sigma_y^2=\sigma_{y0}^2+\sigma_y^2 f(x_c-x_0),\ \sigma_z^2=\sigma_{z0}^2+\sigma_z^2 f(x_c-x_0).$$

Also there are given the formulas for determining the mass of vapor entering the room when evaporated from the open surface of the liquid.

$$M_u=WF_u\tau, \quad (2)$$

where W – is the intensity of the evaporation from the open surface, kg / m^2 s; F_u - the evaporation area, m^2; τ - the time of evaporation, p.

$$W=10^{-6}\cdot\eta\cdot M\cdot P_S, \quad (3)$$

where η – is a coefficient, accepted for tab. 3 [5], depending on the speed and temperature of the air flow; M – the molecular weight; P_S – the pressure of the saturated vapors, kPa.

The indicated method does not take into account the change in the rate of the evaporation of the liquid at the wind speeds more than 1 m / s, the temperature of its surface layer, which as a rule, is usually different from the environment temperature, the change in the pressure of saturated vapors, depending on the time of this evaporation and the height of the liquid layer.

Given these restrictions, it is inappropriate to use this technique to determine the intensity of the evaporation from the open surface to the environment, because the estimated calculations will be significantly different from the actual ones.

Therefore, the method proposed by the U.S. Environmental Protection Agency was used to estimate the danger zone, which is determined by the influence of reservoirs for storing light petroleum products during their natural ventilation for the purpose of degassing at the stage of pre-repair works. [6]. The Office of Emergency Management Center, EPA, developed the software ALOHA®, which is used to calculate the concentrations by the evaporating of the pollutants as a result of their input to the oil refinery (IOR) under the different conditions.

All assumptions about the extent of evaporation in the process of risk assessment focus on the worst consequences.

The degree of contamination was ranked according to concentrations of the Acute Exposure Guideline Levels (AEGL) concentrations [7]. According to AEGLs, 3 levels of the concentration are determined: AEGL-1, AEGL-2 and AEGL-3, respectively.

In Ukraine, the value of the maximum permissible concentration for gas vapors in the air at the level of 5 mg/m^3 [8] is adopted. According to the standards of the European Community, the total organic compounds content is 35 g/m^3 and EPA is 10 g/m^3. The regulation of the gasoline emissions in accordance with the

German standard TA-Luft, the emission limit value of total organic compounds is 0.15 g/m^3 [9-11].

In order to calculate the air pollution zone by the gas vapor, a vertical steel reservoir was selected at the Shebelinsky oil refinery in the Kharkiv region of Ukraine. The calculation was based on the given conditions of the terrain, the type of the shelter capacities, physical and chemical properties of chemicals removed from the reservoir in the atmosphere, meteorological and climatic parameters, and others like that.

The algorithm for the diffusion of pollutants can be represented by one of the possible methods, such as: the Gaussian model of the dispersion or the model of the dispersion of heavy gases. Referring to the initial data on the estimated situation of the release of steam-air mixture of petroleum products into atmospheric air, simulation was conducted using a dispersive model of heavy gases [12].

Using the ALOHA® software and source data, a calculation of the pollution zone and concentration levels was performed during degassing of a reservoir for 5,000 m^3. The results are shown in Fig. 2 and 3. The results of the distribution of the atmospheric air pollution levels in the vapor of the gasoline are plotted on the map of the area with the indicated location of the reservoirs. Three zones are given based on the value of the maximum permissible concentration of MPC for gasoline or isooctane, equal to 5 mg/m^3. These zones are painted in three different colours: red, orange and yellow to reduce the level of danger. The text information on the program screen indicates the size of the specified hazardous zones:

- red: 1,2 kilometer - 5 mg/m^3;
- orange: 1.6 kilometers - 3 mg/m^3;
- yellow: 2.9 kilometers - 1 mg/m^3.

In fig. 2 is shown the zone of the active air pollution by the vapor of the gasoline. In the case of being the population in the red zone there is a real danger of the acute toxic effects.

The fires and explosions on the tanks with easy-flammable substances and easy-flammable liquids often happen during the cleaning, preparation for repairing and directly during the repairing work [13, 14].

Fig. 3 shows the area of the fire hazard of gas vapors, for which the concentration is in the flammable range between the lower and upper limits of the explosion (NMW and IWB). These limits are determined in percentages that reflect the concentration of the fuel (the vapors of the chemicals) in the air. In the case of a collision of the chemical vapor with a source of ignition (for example, a spark), the combustion process occurs only if the value of the concentration of the fuel in the air is between LMW and IVF.

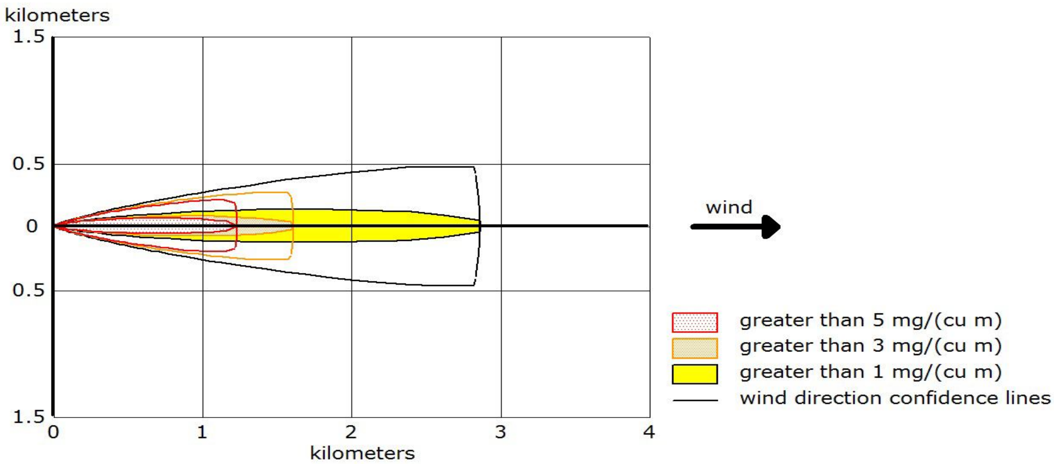

Fig. 2. Pollution from gas vapors during the natural ventilation of tanks

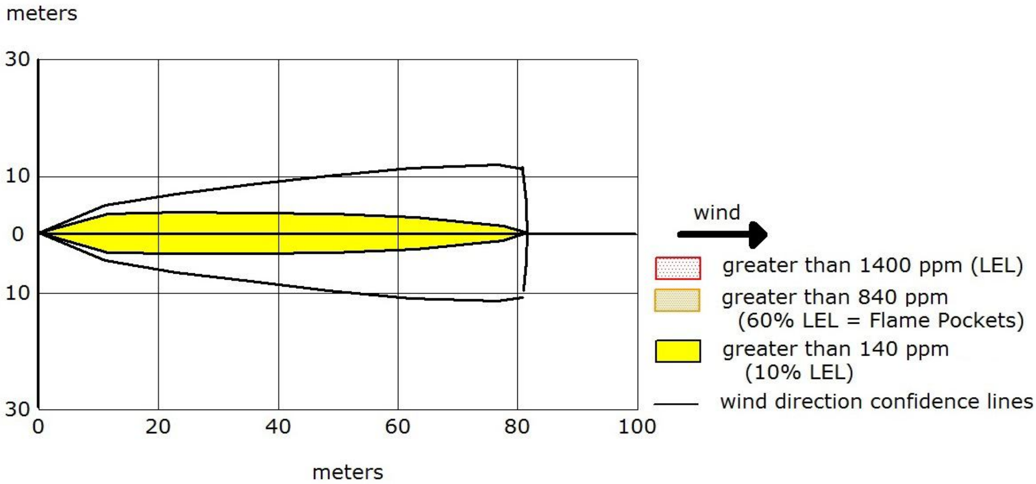

Fig. 3. Dimensions(size) of the flammable zone for gas vapors

ALOHA uses 60% of the NMS as the default level for the highest threat zone (red), as some experiments have shown that fires can occur in the places where the average concentration exceeds this level. Another typical level of the threat which is used by respondents is 10% of LMW, which is the standard hazard rate for a medium-threat zone (yellow).

As it can be seen from Fig. 3, there are no zones of high and medium danger for the given conditions, therefore the probability of the fire is minimal (10% of NME), and is characterized by an area of 80 m.

Another no less important indicator is the area of the explosive danger.

The excessive voltage, which is also called an explosive wave, means a sudden onset of the pressure wave after the explosion.

This voltage wave is due to the energy which releases during the initial explosion - the more initial explosion, the greater the pressure wave.

ALOHA uses the surplus pressure (in psi, psi) based on the review of several commonly used sources of the excessive pressure and the explosions:

- 8.0 pounds / square. inch (destruction of the buildings);
- 3.5 pounds / square. inch (possible the serious damage);
- 1.0 pounds / square. inch (destruction of the glass).

For the considered of this situation, the size of the zone with the serious damage is 13 m in the direction of the prevailing wind in accordance with the wind rose (Fig. 4).

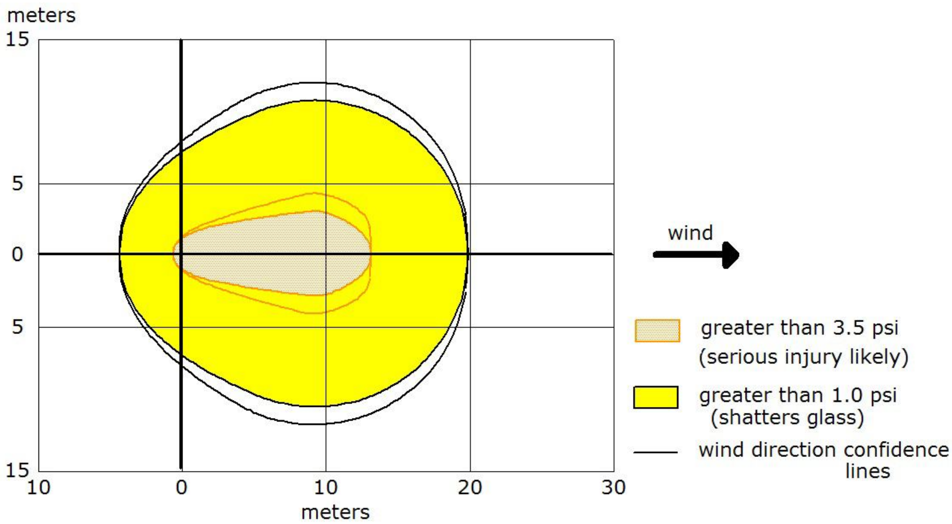

Fig. 4. Explosion region of the cloudy steam of the gasoline

Conclusions

On the basis of the conducted researches, the area of the active contamination was identified in the course of the forced ventilation with the traditional air supply, using software for modeling the dispersion of the pollutants. It was established that during the forced degassing of PBC-5000 reservoir 1.5 tons of petroleum vapors enter the atmosphere. The software, ALOHA®, evaluates the toxic zone, fire hazard zone and the gas explosion area by the natural ventilation of the tanks.

The size of the zone of the acute toxic effects on the population consists of 1,2 km and was calculated for the given initial conditions, the zone of fire danger is 80 m, the explosion zone does not exceed 13 m.

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Оцінка масштабів і ризику виникнення техногенних ситуації під час процесу дегазації резервуарів зберігання світлих нафтопродуктів

А. М. Роянов, С. В. Гарбуз

Предметом дослідження в даній статті є процеси підвищення рівня екологічної та пожежної безпеки при дегазації вертикальних циліндричних резервуарів із залишками світлих нафтопродуктів. **Мета даної роботи** полягає в контролі рівня екологічної та пожежної безпеки територій в зоні впливу нафтогазозберегаючих об'єктних комплексів з використанням методу, запропонованого Агентством з охорони навколишнього середовища США. Управління надзвичайними ситуаціями (EPA) розробило програмний продукт ALOHA®, який використовується для розрахунку розподілу концентрацій при випаровуванні забруднюючих речовин в результаті їх потрапляння на станцію переробки нафти в різних умовах. Завдання полягає в тому, щоб оцінити рівень антропогенного тиску на навколишнє середовище та вплив парів нафтопродуктів шляхом примусової дезактивації резервуарів для зберігання легкої нафти. **Використовувані методи** - це дослідження, що проводяться з використанням газового аналізу для визначення якісного та кількісного складу газових сумішей на виході з резервуарів з використанням сучасного випробувального обладнання. Були отримані наступні результати. **В результаті** проведених досліджень була розроблена методика розрахунку і прогнозування рівня техногенного навантаження на атмосферне повітря шляхом моделювання і прогнозування зон активного забруднення викидами пароповітряних вуглеводневих сумішей. **Висновки.** На підставі проведених досліджень була визначена зона активного забруднення при проведенні примусової дегазації з подачею повітря, яка здійснювалася традиційним методом з використанням програмного забезпечення для моделювання розсіювання забруднюючих речовин. Встановлено, що при примусової вентиляції резервуара РВС-5000 в природне середовище потрапляє 1,5 тонни пароповітряної суміші. Використовуючи програмний продукт ALOHA®, була оцінена небезпечна зона і зона можливого вибуху парів бензину при природній дегазації резервуарів із зберіганням світлих нафтопродуктів. Розмір зони сильних токсичних впливів на населення досягає 1,2 км, вона розрахована для заданих початкових умов, зона пожежної небезпеки становить 80 м, зона вибуху не перевищує 13 м.

Ключові слова: примусова вентиляція; інтенсивність випаровування; очищення резервуарів; забруднення навколишнього середовища; ризик вибуху.

Оценка масштабов и риска возникновения техногенных ситуации во время процесса дегазации резервуаров хранения светлых нефтепродуктов

А. Н. Роянов, С. В. Гарбуз

Предметом исследования в данной статье являются процессы повышения уровня экологической и пожарной безопасности при дегазации вертикальных цилиндрических резервуаров с остатками светлых нефтепродуктов. **Цель данной работы** заключается в контроле уровня экологической и пожарной безопасности территорий в зоне влияния нефтегазосберегающих объектных комплексов с использованием метода, предложенного Агентством по охране окружающей среды США. Управление чрезвычайными ситуациями (EPA) разработало программный продукт ALOHA®, который используется для расчета распределения концентраций при испарении загрязняющих веществ в результате их попадания на станцию переработки нефти в различных условиях. Задача состоит в том, чтобы оценить уровень антропогенного давления на окружающую среду и влияние паров нефтепродуктов путем принудительной дезактивации резервуаров для хранения легкой нефти. **Используемые методы** - это исследования, проводимые с использованием газового анализа для определения качественного и количественного состава газовых смесей на выходе из резервуаров с использованием современного испытательного оборудования. Были получены следующие **результаты**. В результате проведенных исследований была разработана методика расчета и прогнозирования уровня техногенной нагрузки на атмосферный воздух путем моделирования и прогнозирования зон активного загрязнения выбросами паровоздушных углеводородных смесей. **Выводы.** На основании проведенных исследований была определена зона активного загрязнения при проведении принудительной дегазации с подачей воздуха, которая осуществлялась традиционным методом с использованием программного обеспечения для моделирования рассеивания загрязняющих веществ. Установлено, что при принудительной вентиляции резервуара РВС-5000 в природную среду попадает 1,5 тонны паровоздушной смеси. Используя программный продукт ALOHA®, была оценена опасная зона и зона возможного взрыва паров бензина при естественной дегазации резервуаров с хранением светлых нефтепродуктов. Размер зоны сильных токсических воздействий на население достигает 1,2 км, она рассчитана для заданных начальных условий, зона пожарной опасности составляет 80 м, зона взрыва не превышает 13 м.

Ключевые слова: принудительная вентиляция; интенсивность испарения; очистка резервуаров; загрязнение окружающей среды; риск взрыва.