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БИОИНДИКАЦИОННЫЕ ИССЛЕДОВАНИЯ СОСТОЯНИЯ ПРИДОРОЖНЫХ ЭКОСИСТЕМ

Проведено исследование состояния придорожных экосистем вдоль автомагистралей Украины различных категорий. Исследовались участки на дорогах М02, М03, Н07, Н12 и Р44. Оценка воздействия на экосистемы осуществлялась биоиндикационными методами, с помощью лишайников и высших растений (овес). Показано, что уровень загрязнения придорожных экосистем тем больше, чем выше категория дороги, а соответственно интенсивность движения автотранспорта.

Ключевые слова: придорожные экосистемы, автомагистрали Украины, биоиндикационные методы, индекс атмосферной чистоты.

__Plyatsuk Leonid,__ Doctor of Technical Sciences, Professor, Department of Applied Ecology, Sumy State University, Ukraine, e-mail: l.plyacuk@ecolog.sumdu.edu.ua, ORCID: https://orcid.org/0000-0003-0095-5846

__Moiseev Viktor,__ PhD, Professor, Department of Chemical Technology and Industrial Ecology, National Technical University «Kharkiv Polytechnic Institute», Ukraine, e-mail: kafedrahtpe@i.ua, ORCID: https://orcid.org/0000-0002-3217-1467

__Vaskin Roman,__ PhD, Lecturer, Department of Applied Ecology, Sumy State University, Ukraine, e-mail: r.vaskin@pk.sumdu.edu.ua, ORCID: https://orcid.org/0000-0003-4382-0327

__Ablieieva Iryna,__ PhD, Assistant, Department of Applied Ecology, Sumy State University, Ukraine, e-mail: i.ableyeva@ecolog.sumdu.edu.ua, ORCID: https://orcid.org/0000-0002-2333-0024

__Vaskina Iryna,__ Assistant, Department of Applied Ecology, Sumy State University, Ukraine, e-mail: irulik.vaskina@gmail.com, ORCID: https://orcid.org/0000-0001-5904-9640

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Khalmuradov B., Harbuz S., Ablieieva I.

ANALYSIS OF THE TECHNOGENIC LOAD ON THE ENVIRONMENT DURING FORCED VENTILATION OF TANKS

Досліджено вплив світлих нафтопродуктів (бензин, дизельне паливо, гас) на стан навколишнього середовища в зоні впливу резервуарів зберігання цих продуктів. Обгрунтовано, що застосування примусової вентиляції з традиційною подачею повітря є екологічно небезпечною операцією. Доведено, що альтернативою цьому рішенню є ежекторний-вихровий метод подачі повітря при дегазації резервуарів з подальшим уловлюванням парів нафтопродуктів за допомогою абсорбційної-конденсаційної установки.

Ключові слова: *примусова вентиляція, ежекторний спосіб подачі повітря, екологічна небезпека, резервуари зберігання нафтопродуктів, оцінка ризику.*

1. Introduction

Storage tanks for oil products are environmentally hazardous sources of anthropogenic impact on the environment, acting as objects of uncontrolled emissions of steam-air mixtures or vapor-gas-air mixtures and spills of oil products, followed by fires and explosions. The environmental relevance of storage is essentially dependent on its potential to pollute the environment and on the physical and chemical properties of the stored substances. Petroleum tanks are used on the farm to store gasoline and diesel fuel. Properly designed petroleum storages must prevent leaks and the potential contamination of soils, surface water or groundwater. The analysis of the sources of environmental impact during the operation of the reservoirs indicates that the vertical steel tanks, even during normal operation, are environmentally hazardous.

Preparation of tanks with residues of petroleum products for fire repair works is one of the most complex and environmentally hazardous technological operations in the process of exploitation of tanks. Fires and explosions on reservoirs from flammable substances and flammable liquids often occur during cleaning and preparation for repairs, and in the course of repair work directly [1]. The share

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of fires in the industrial sector during routine, repair and fire work is 13 % of the total number of fires. At the same time, at enterprises of the oil and gas complex, the share of fires in repair and fireworks reaches 50 %, and on reservoirs – 70 %. It is explained by the fact that light oil products are highly flammable due to availability to be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air and may travel to source of ignition and flash back. Most vapors are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a (P) may polymerize explosively when heated or involved in a fire. Run off to sewer may create fire or explosion hazard.

Health hazard assessment of the petroleum vapors of the tanks indicates the following. Inhalation or contact with material may irritate or burn skin and eyes. Fire may produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Run off from fire control or dilution water may cause pollution [2].

Saturated aliphatic hydrocarbons, such as isooctane, may be incompatible with strong oxidizing agents like nitric acid. Charring of the hydrocarbon may occur followed by ignition of unreacted hydrocarbon and other nearby combustibles. In other settings, aliphatic saturated hydrocarbons are mostly unreactive. They are not affected by aqueous solutions of acids, alkalis, most oxidizing agents, and most reducing agents [3].

Regular operation, pre-repair and repair work on tanks with oil products is a source of anthropogenic impact on the environment due to the emergence of environmentally hazardous situations, accompanied by explosions and fires, and pose a real threat to life and health of the population. That's why research and assessment of the reduction in the load on nature when introducing forced ventilation of tanks by means of ejector-vortex air supply with subsequent utilization of the injected petroleum products is a very topical scientific and practical task of improving the ecological safety of the territories.

2. The object of research and its technological audit

The object of research is an aboveground vertical steel tank, used as storage tank for light oil products (gasoline, diesel fuel, kerosene). The vertical steel tank (VST) consists of a cylindrical body, a flat bottom and a fixed roof (a self-supporting conical roof, the bearing capacity of which is provided by a conical shell of the deck, a skeleton conical roof consisting of carcass elements and flooring). The vertical tank is made with a floating roof or pontoon. The floating roof, located inside the reservoir on the surface of the liquid, is designed to reduce its loss from evaporation and to exclude the possibility of an explosion and fire.

The test vertical cylindrical tank has an anticorrosion coating. As a basis, a two-layer primer is used, along which enamel is applied. The thermal insulation is made on the wall and on the roof of the tank. During the technological audit of the object of research it was discovered that it is equipped with additional tank equipment, including level control devices, breathing fittings, fire safety devices, lightning protection device.

Main technical characteristics of the vertical steel tank 5000 m^3 is shown in Table 1.

The design of the tank with the technical characteristics given in Table 1 is shown in Fig. 1.

Table 1

Technical characteristics of VST 5000 m^3

Indicator name	Value
Nominal volume, m^3	5000
Internal diameter of the wall, m	20.92
Wall height, m	14.90
Density of the product, kg/m^3	900
Estimated height of filling, m	14.90
Wall of VST-5000	
Number of belts, pieces	10
Thickness of upper belt, mm	6
Thickness of the lower belt, mm	12
Bottom of VST-5000	
Number of edges, pieces	12
Thickness of the central part, mm	5
Thickness of edges, mm	10
Roof of VST-5000	
Number of beams, pieces	32
Weight of constructions, kg	
Wall	64420
Bottom	17732
Roof	26201
Stairs	1480
Platforms on the roof	3051
Hatches and nozzles	2182

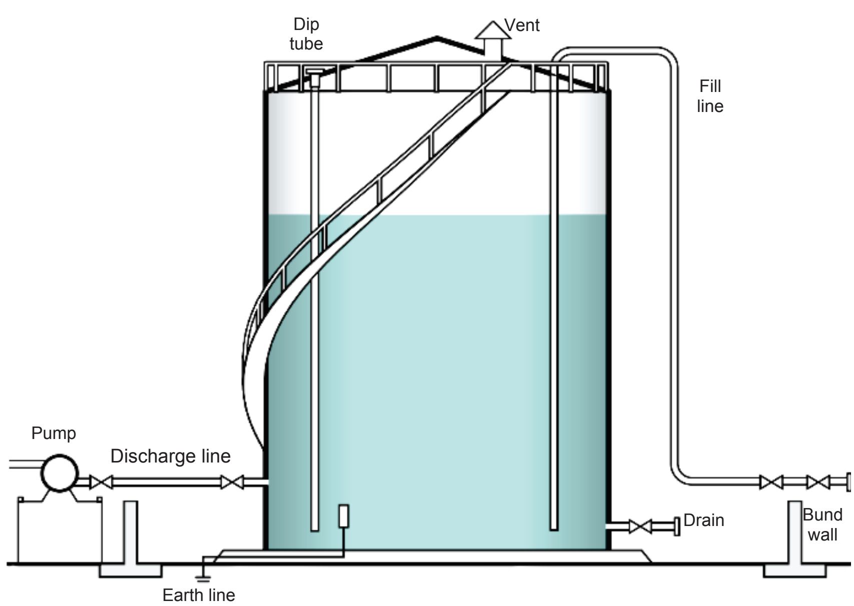

Fig. 1. Typical vertical storage tank (top filled)

In the process of exploitation of such tanks, their wear and tear occurs, which requires the elimination of the wall and bottom shell defects, mainly using fireworks. In this regard, the preparation of tanks, including degassing through the ventilation of the internal space, is an important integral stage of reservoir maintenance.

One of the most problematic places of this operation is extremely high level of explosion and fire risk, and therefore, a significant danger to the life and health of people in the zone of influence of reservoirs. Within forced ventilation of the VST-5000 tank, 1.5 tons of petroleum products vapor enters the atmospheric air. To address this shortcoming, the application of the absorption-condensation technology of vapor recovery of oil products, the efficiency of which reaches 99 %, is proposed in the paper.

3. The aim and objectives of research

The aim of research is determination of the level of anthropogenic load on the environment in the operation of vertical storage tanks for light oil products, as well as the rationale for environmental safety due to the introduction of forced ventilation with an ejector air supply method.

To achieve this goal, the following tasks were solved:

1. To identify zones of active pollution in the implementation of natural ventilation or forced with traditional air supply, using software to simulate the dispersion of pollutants.

2. To estimate of toxic area, flammable threat zone and blast area of gasoline vapor during natural ventilation of tanks.

3. To substantiate the effectiveness and environmental friendliness of the proposed solution based on the calculation of the atmospheric pollution index and risk assessment.

4. Research of existing solutions of the problem

Regulations on controlling organic vapor pollutants in air have been issued world-wide. In the ambient air quality standards produced by the US Environmental Protection Agency, the maximum 3-hour concentration of hydrocarbon content is 0.24 ppm, not to be exceeded for more than a year. The recently passed European Community stage emissions limit is 35 grams' total organic compounds (TOC) per cubic meter gasoline loaded (35 g TOC/m^3). Similarly, the United States Environmental Protection Agency Standard 40 CFR Part 63 has established an emission limit of 10 g TOC/m^3. The German TA-Luft Standard, the most stringent known gasoline emission regulation, has set an emissions limit to 150 mg TOC (excluding methane) per cubic meter of loaded product (0.15 g TOC/m^3) [4–6].

Gaseous and liquid streams to environmental surroundings from storage in tanks are shown in Fig. 2.

Combustion of liquids occurs when flammable vapors released from the surface of the liquid ignite. The amount of flammable vapor given off from a liquid, and therefore the extent of the fire or explosion hazard, depends largely on the temperature of the liquid, its volatility, how much of the surface area is exposed, how long it is exposed for, and air movement over the surface. Other physical properties of the liquid, such as flashpoint, auto-ignition temperature (AIT), viscosity, lower explosion limit (LEL) and upper explosion limit (UEL), give further information as to how vapor/air mixtures may develop and also on the potential hazards.

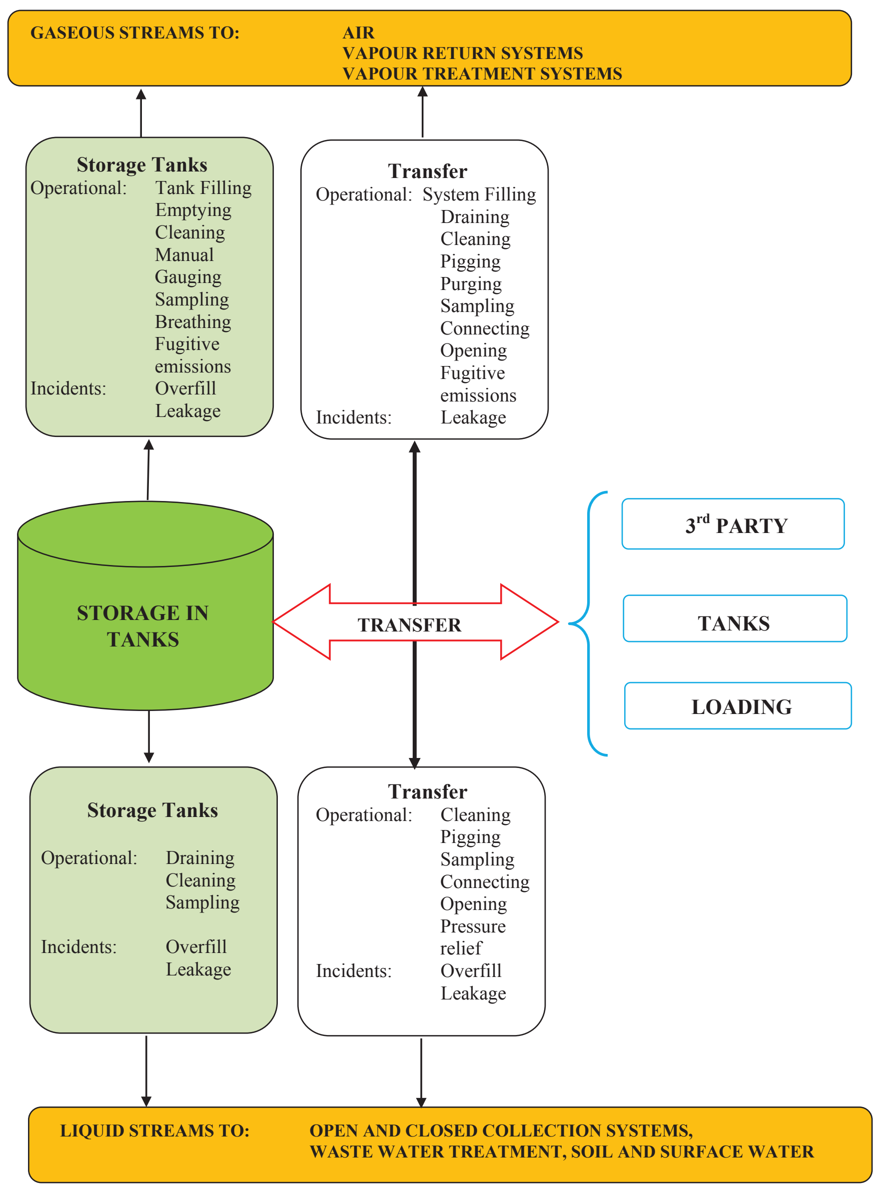

Fig. 2. Flow chart with potential emissions resulting from aboveground and underground storage facilities

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Regulation 7 of Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) requires employers to classify places at the workplace where an explosive atmosphere may occur into hazardous and non-hazardous areas. The aim is reducing to a minimum acceptable level the probability of a flammable atmosphere coinciding with an electrical or other ignition source [7].

For flammable vapors there are three classes of hazardous area or zone: zone 0, zone 1 and zone 2. A zone is an area around a process or activity where a flammable atmosphere may be present.

Zone 0 is a place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapor or mist is present continuously or for long periods or frequently.

Zone 1 is a place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapor or mist is likely to occur in normal operation occasionally.

Zone 2 is a place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapor or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only [8].

Example of hazardous area classification for a fixed-roof tank is shown in Fig. 3.

The efficiency of the different technologies is product dependent, e. g. the adsorption efficiency of activated carbon is much higher for butane than it is for methane. Increased overall emission reduction efficiency can be achieved by having two systems in series, e. g. a membrane first stage treatment unit followed by a thermal oxidizer as a second stage to further control the emissions from the first stage.

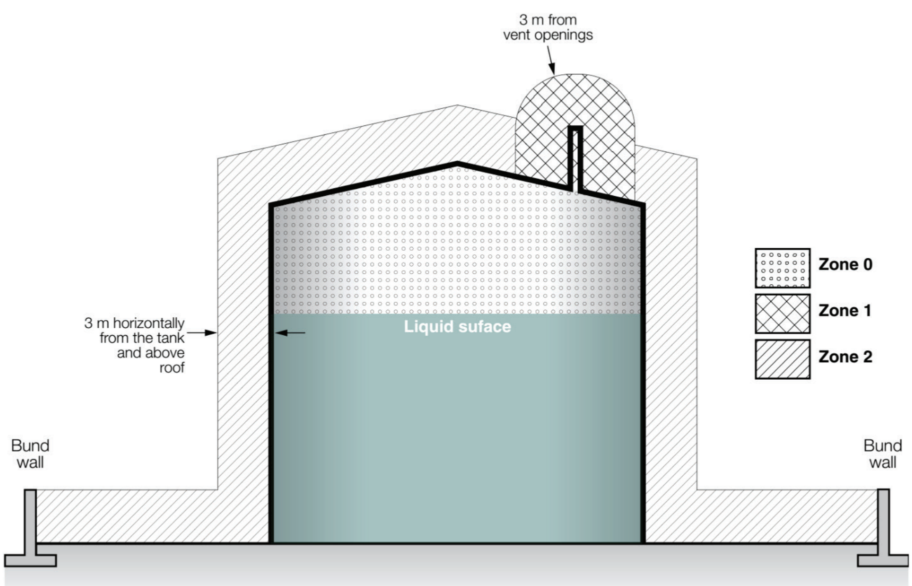

Fig. 3. Vertical storage tank – typical hazardous area classification

However, the incremental reduction in emissions may be small compared to operating only a single stage process. For example, gasoline single stage VRUs (Vapor Recovery Units) can achieve an average efficiency of 99 %. Adding a second stage would remove another 0.9 %. The capital and operating costs of the second stage, therefore, result in a very poor cost per ton emission abated effectiveness [9].

To date, many manuals have been developed to carry out pre-repair works, including the implementation of degassing of tanks [10–12]. To prevent air pollution by vapors of ventilated petroleum products, in particular gasoline, it is suggested to carry out forced ventilation of tanks with an ejector-vortex method of supplying air to the internal space [13].

However, there are no calculations for assessing the zone of active pollution due to natural ventilation or forced ventilation with traditional air supply. Based on the foregoing, there is a need to assess the reduction of the man-made impact on the environment when implementing the proposed solution.

5. Materials of research

5.1. Air hazard modeling methodology. Modeling of active pollution zones during degassing of tanks with petroleum products was carried out using program Areal Locations of Hazardous Atmospheres (ALOHA). ALOHA® is the air hazard modeling program in the Computer-Aided Management of Emergency Operations (CAMEO®) software suite developed jointly by National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA). ALOHA allows to enter details about a real or potential chemical release, and then it will generate threat zone estimates for various types of hazards. ALOHA can model toxic gas clouds, flammable gas clouds, BLEVEs (Boiling Liquid Expanding Vapor Explosions), jet fires, pool fires, and vapor cloud explosions. CAMEO Chemicals is a database of hazardous chemical datasheets that emergency responders and planners can use to get response recommendations and predict hazards such as explosions or toxic fumes. It is part of the CAMEO® software suite, developed jointly by NOAA and EPA. The threat zone estimates are shown on a grid in ALOHA, and they can also be plotted on maps in MARPLOT®, Esri's ArcMap, Google Earth, and Google Maps.

The red threat zone represents the worst hazard level, and the orange and yellow threat zones represent areas of decreasing hazard.

5.2. Input dates for pollution zones modeling. To calculate the zones of atmospheric air pollution with petrol vapors, a vertical steel tank was set up in the Shebelinka oil refinery, Kharkiv region, Ukraine.

The calculation was based on the set location conditions, the type of shelter, the physical and chemical properties of chemicals removed from the reservoir into the atmospheric air, meteorological and climatic parameters, and so on (Table 2).

Table 2

Input dates for releasing modelling

Site data	
Location	ANDREEVKA, UKRAINE
Building Air Exchanges Per Hour	0.85 (sheltered single storied)
Coordinates	Latitude 49°33′19″ N Longitude 36°37′49″ E
Chemical data	
Chemical Name	ISOOCTANE
CAS Number	540-84-1
Molecular Weight	114.23 g/mol
PAC-1	230 ppm
PAC-2	830 ppm
PAC-3	5000 ppm
LEL	9500 ppm
UEL	60000 ppm
Ambient Boiling Point	98.3 °C
Vapor Pressure at Ambient Temperature	0.051 atm
Ambient Saturation Concentration	51.929 ppm or 5.19 %
Atmospheric data (manual input of data)	
Wind	5 meters/second from 60° true at 2 meters
Ground Roughness	open country
Cloud Cover	3 tenths
Air Temperature	20 °C, No Inversion Height
Relative Humidity	25 %
Source strength	
Source Height	16.9 meters
Direct Source	200 grams/sec
Release Duration	60 minutes
Release Rate	12 kilograms/min
Total Amount Released	720 kilograms

5.3. Methods of air pollution assessment. The level of atmospheric pollution and the degree of danger to the population in the zone of influence of oil product vapor emissions were estimated using the air pollution index (API). The computation of the API is based on the assumption that, when the values are at the MPC level, all harmful substances are characterized by an identical influence on humans and that, with a further increase in concentration, the degree of their harm increases with a different rate which depends on a hazard class of a given pollutant. Calculation of the API was carried out according to the formula [14]:

$$API_i = \left(\frac{q_{mean.i}}{MPC_{d.m.i}} \right)^{K_i}, \qquad (1)$$

where *API* is air pollution index; $q_{mean.i}$ is mean annual (or mean monthly) concentration of the *i*-th pollutant, mg/m^3; $MPC_{d.m.i}$ is its daily mean maximum permissible concentration mg/m^3; K_i is a dimensionless coefficient allowing the degree of air pollution by the *i*-th pollutant to be adjusted to the degree of air pollution by substances of third hazard class.

The values of K_i are 0.85, 1.0, 1.4 and 1.7, respectively, for hazard classes 4, 3, 2 and 1 of a given pollutant. Petroleum substance group (isooctane, gasoline) refers to third hazard class that's why it is used coefficient K_i at the level of 1.

5.4. Risk assessment according to ALOHA. Risk assessment in ALOHA is carried out using a Level of Concern (LOC) that is a threshold value of a hazard (toxicity, flammability, thermal radiation, or overpressure); the LOC is usually the value above which a threat to people or property may exist. There are following types of LOC that can be used taking into account input dates specifications: AEGLs, ERPGs, TEELs, PACs, IDLH or user specified such as MPL. Discuss the advantages and disadvantages, as well as the specifics of using each of them for a particular situation in accordance with given conditions.

1. AEGLs (Acute Exposure Level Guidelines) are used preferentially because they are the best public exposure LOCs to date. They undergo a rigorous review process, have multiple exposure durations, and are designed as guidelines for nearly all members of the general public including sensitive individuals [15]. AEGLS are expressed as specific concentrations of airborne chemicals at which health effects may occur. They are designed to protect the elderly and children, and other individuals who may be susceptible. AEGLs assigned 1, 2 or 3 according to severity of effects

AEGLs are calculated for five relatively short exposure periods – 10 minutes, 30 minutes, 1 hour, 4 hours, and 8 hours – as differentiated from air standards based on longer or repeated exposures. AEGL «levels» are dictated by the severity of the toxic effects caused by the exposure, with Level 1 being the least and Level 3 being the most severe. All levels are expressed as parts per million or milligrams per cubic meter (ppm or mg/m^3) of a substance above which it is predicted that the general population could experience, including susceptible individuals.

2. ERPGs (Emergency Response Planning Guidelines) are based on experimental data, but unlike AEGLs they are only available for a 60-minute exposure duration and they are not designed as guidelines for sensitive individuals. ERPGs estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. Sensitive members of the public such as old, sick, or very young people aren't covered by these guidelines and they may experience adverse effects at concentrations below the ERPG values. A chemical may have up to three ERPG values, each of which corresponds to a specific tier of health effects.

3. TEELs (Temporary Emergency Exposure Limits) are guidelines designed to predict the response of members of the general public to different concentrations of a chemical during an emergency response incident.

4. PACs (Protective Action Criteria for Chemicals) combine all three common public exposure guideline systems (AEGLs, ERPGs, and TEELs) and implements a hierarchy-based system.

5. IDLHs (Immediately Dangerous to Life and Health limits) are workplace exposure limits that are meant to protect workers when they are exposed to a toxic chemical in the course of their work. IDLH limits are used when no public exposure guidelines are defined for a given chemical. An IDLH limit is a workplace exposure limit that is used primarily for making decisions regarding respirator use. However, unlike the three-tiered public

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exposure guidelines, only a single IDLH value is defined for applicable chemicals.

6. MPC (Maximum Permissible Level) is level, usually a combination of time and concentration, beyond which any exposure of humans to a chemical or physical agent in their immediate environment is unsafe [16].

6. Research results

Spreading algorithm for downwind dispersion may be provided one of the possible method such as follows: Gaussian dispersion model or Heavy Gas dispersion model. Referring to the initial data on the estimated situation of the entry of a steam-air mixture of petroleum products into the atmospheric air (Table 1) simulation was carried out using Heavy Gas dispersion model. The heavy gas dispersion models can be divided into four groups: simple/empirical models, intermediate/integral and shallow layer models, advanced/Lagrangian particle and Lagrangian Gaussian puff models, sophisticated/CFD models [17].

Three zones were given based on the value of MPC for gasoline or isooctane that is equal 5 mg/m^3 (5 mg/(cu·m)). These zones are colored in three different colors: red, orange and yellow in order of decreasing danger level. The text information on the program display indicates the dimensions of the designated danger areas:

– Red: 1.2 kilometers – (5 mg/(cu·m));
– Orange: 1.6 kilometers – (3 mg/(cu·m));
– Yellow: 2.9 kilometers – (1 mg/(cu·m)).

Fig. 4 shows the zone of active pollution of atmospheric air with petrol vapors. If there is a population in the red zone, there is a real danger of acute toxic effects.

An ALOHA threat zone estimate displayed on a Google Earth map (Fig. 5). The red, orange and yellow zones indicate areas where specific Level of Concern thresholds were exceeded.

Fig. 6 shows the rate of change in the concentration of gasoline vapor at a distance of 1 km from the location of the reservoir for storing this petroleum product during ventilation without cleaning the exhaust steam-air mixture.

Fig. 7 shows flammable threat zone for gasoline vapor that is the part of a flammable vapor cloud where the concentration is in the flammable range, between the Lower and Upper Explosive Limits (LEL and UEL).

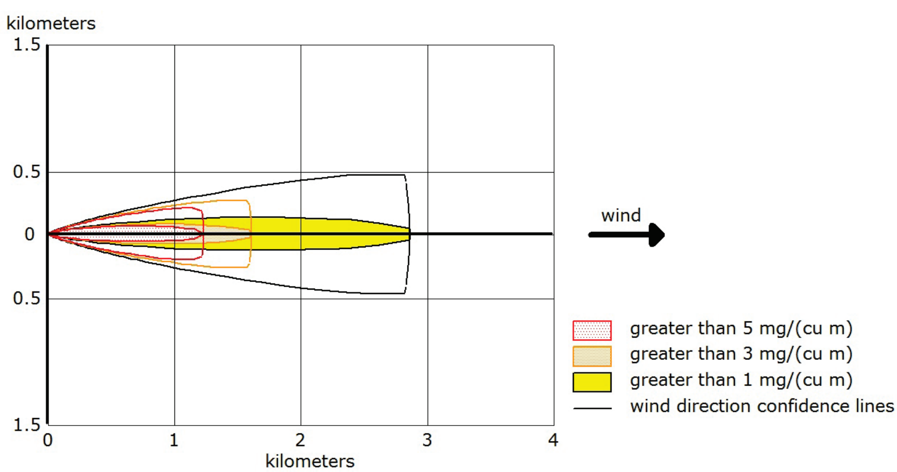

Fig. 4. Toxic area of gasoline vapor during natural ventilation of tanks

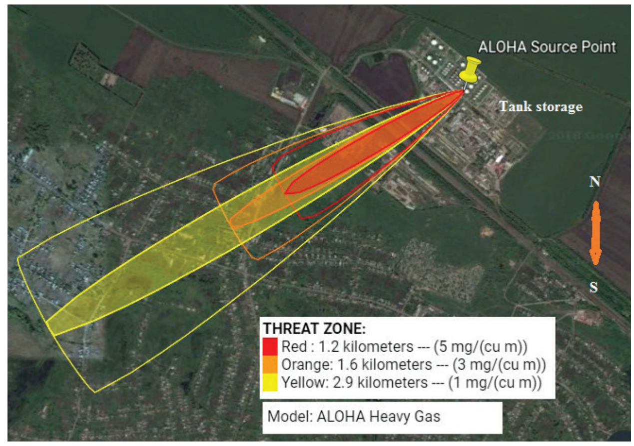

Fig. 5. Threat zone on a Google Earth map for the study area

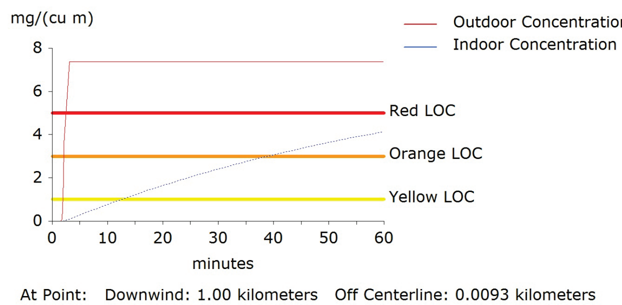

Fig. 6. Concentration of petrol vapor at a distance of 1 kilometer in the southwest direction

These limits are percentages that represent the concentration of the fuel (that is, the chemical vapor) in the air. If the chemical vapor comes into contact with an ignition source (such as a spark), it will burn only if its fuel-air concentration is between the LEL and the UEL because that portion of the cloud is already pre-mixed to the right mixture of fuel and air for burning to occur. ALOHA uses 60 % of the LEL as the default LOC for the red threat zone, because some experiments have shown that flame pockets can occur in places where the average concentration is above that level. Another common threat level used by responders is 10 % of the LEL, which is ALOHA's default LOC for the yellow threat zone.

As can be seen from the Fig. 6, for the given conditions there are no red and orange zones. And this means that the danger of ignition is minimal, as indicated by the yellow zone of 80 m. The yellow zone is characterized by 10 % of the LEL.

Another no less important indicator is the explosion zone. Overpressure, also called a blast wave, refers to the sudden onset of a pressure wave after an explosion.

This pressure wave is caused by the energy released in the initial explosion—the bigger the initial explosion, the more damaging the pressure wave.

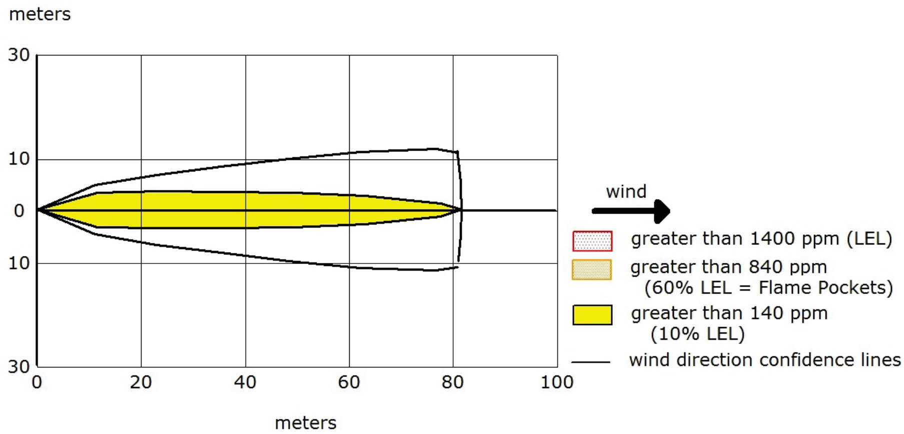

Fig. 7. Flammable threat zone for gasoline vapor

Unlike toxic LOCs, no well-defined guidelines or standards exist to evaluate the overpressure hazard. So, ALOHA uses default overpressure values (in pounds per square inch, psi) that are based on a review of several widely accepted sources on overpressure and explosions:

– 8.0 psi (destruction of buildings);
– 3.5 psi (serious injury likely);
– 1.0 psi (shatters glass).

For the case under consideration, the size of zone with serious injury likely is 13 m in the direction of the prevailing wind (according to the wind rose) as it is shown in Fig. 8.

Calculation of API in accordance with (1) can be carried out as follows:

$$API_g = \left(\frac{8\ \text{mg/m}^3}{5\ \text{mg/m}^3}\right)^1 = 1.6.$$

It is known that the safe state of the environment, in particular atmospheric air, is characterized by the value of this indicator at a level below 1. Under the given conditions, the API is 1.6, which indicates that there is a danger to the population in the zone of influence of gasoline vapor emissions (Fig. 4, 5). Results of modeling and calculation of such zones: toxic area, flammable threat zone and blast area of gasoline vapor during natural ventilation of tanks indicate the following inferences.

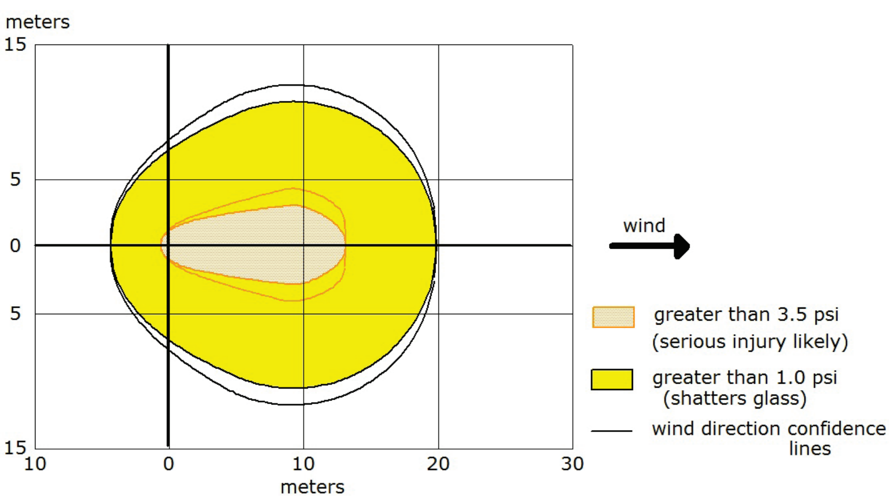

Fig. 8. Blast area of gasoline vapor cloud explosion

The calculation was carried out for a reservoir with a volume of 5000 m^3 at an initial concentration of 300 mg/m^3. The assessment of active pollution zones was carried out with the calculation that the release of petroleum vapor is 200 g/s for 60 minutes. Other baseline data are given in Table 1.

Using the software product ALOHA it was determined that zone of acute toxic effect is 1.2 kilometers (5 mg/(cu·m)); zone of toxic effect of medium strength is 1.6 kilometers (3 mg/(cu·m)); zone of low toxicity is 2.9 kilometers (1 mg/(cu·m)). The population that is within these zones is in the field of increased dangers.

To reduce the emission of hydrocarbon vapors into the atmosphere when decontaminating land tanks for storage of light oil products, it is necessary to shorten the time of its carrying out. The task is achieved due to the fact that during forced ventilation, the supply of atmospheric air is carried out from opposite sides of the tank through two rotary air ejectors.

7. SWOT analysis of research results

Strengths. Using the ejector method of degassing tanks for storage of light oil products allows to reduce the time of degassing of tanks of various shapes and sizes. This is achieved by intensifying the mixing of the internal vapor-gas medium with atmospheric air. Strengths also include a high degree of capture, the technology does not have high or low temperatures and pressures, small capital and operating costs, no maintenance sites, reliable operation of the installation in summer and winter; easy installation and maintenance of the installation.

Weaknesses. It is possible to attribute to the weak sides of the installation that the relative gas velocity is higher than the recommended values for atmospheric devices, which reduces the absorption efficiency, additional pumps are required for periodically feeding and pumping the absorbent (oil product) from the underground reservoir to the storage tank. Forced ventilation of tanks with an ejector-vortex method of air supply requires additional energy.

Opportunities. The impulse of absorption-condensation technology of vapor recovery of petroleum products allows to eliminate harmful emissions to the atmosphere, since its efficiency reaches 99 %. In this regard, the payment for the environmental tax and for damage to the environment is canceled. Moreover, recovered pairs of petroleum products, in particular gasoline, are sold as a commercial product, which causes additional income. The application of the software product ALOHA allows to predict and evaluate the zone of active contamination quickly and effectively when carrying out the ventilation of tanks by various methods of supplying air.

Threats. The exploitation of vertical steel tanks, including their ventilation, may not always be under the control of the maintenance staff. Various emergencies can lead to the complete destruction of reservoirs. And as a result, fires and explosions occur, which create huge damage to the environment. In addition, people who find themselves in this zone are at very high risk of injury and death.

8. Conclusion

1. The conducted researches identified zones of active pollution in the implementation of natural ventilation or forced with traditional air supply, using software to simulate the dispersion of pollutants. It was determined that within forced ventilation of the VST-5000 tank, 1.5 tons of petroleum products vapor enters the atmospheric air.

2. Using the software product ALOHA®, it was possible to estimate of toxic area, flammable threat zone and blast area of gasoline vapor during natural ventilation of tanks. The size of the zone of acute toxic effects on the population that reaches 1.2 km is calculated for the given initial conditions, the fire danger zone is 80 m and the explosion zone does not exceed 13 m.

3. Based on the analysis of the obtained data, it becomes evident that the proposed method for venting tanks with ejector air supply and subsequent recovery of petroleum product vapors is advisable and environmentally friendly. Calculated atmospheric pollution index and risk assessment exceeds the allowable value. The atmospheric pollution index was estimated at a distance of 1 km from the location of the reservoir. The value of the index API=1.6, which exceeds the standards of maximum permissible indicators.

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АНАЛИЗ ТЕХНОГЕННОЙ НАГРУЗКИ НА ОКРУЖАЮЩУЮ СРЕДУ ПРИ ПРИНУДИТЕЛЬНОЙ ВЕНТИЛЯЦИИ РЕЗЕРВУАРОВ

Исследовано влияние светлых нефтепродуктов (бензин, дизельное топливо, керосин) на состояние окружающей среды в зоне воздействия резервуаров хранения этих продуктов. Обосновано, что применение принудительной вентиляции с традиционной подачей воздуха является экологически опасной операцией. Доказано, что альтернативой этому решению является эжекторно-вихревой метод подачи воздуха при дегазации резервуаров с последующим улавливанием паров нефтепродуктов с помощью абсорбционно-конденсационной установки.

Ключевые слова: принудительная вентиляция, эжекторный способ подачи воздуха, экологическая опасность, резервуары хранения нефтепродуктов, оценка риска.

Khalmuradov Batyr, *PhD, Associate Professor, Department of Civil and Industrial Safety, National Aviation University, Kyiv, Ukraine, e-mail: batyrk@ukr.net, ORCID: http://orcid.org/0000-0003-2225-6528*

Garbuz Sergey, *Lecturer, Department of Fire and Technogenic Security of Facilities and Technologies, National University of Civil Protection of Ukraine, Kharkiv, Ukraine, e-mail: sgarbuz65@gmail.com, ORCID: http://orcid.org/0000-0001-6345-6214*

Ablieieva Iryna, *PhD, Department of Applied Ecology, Sumy State University, Ukraine, e-mail: i.ableyeva@ecolog.sumdu.edu.ua, ORCID: http://orcid.org/0000-0002-2333-0024*