To the Estimation of Atmospheric Air Assessment’ Quality in Areas of Location of gas Stations in an Inhabited Residential Area of Stavropol

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Abstract. Gas filling stations are an integral part of the urban economy and the life of the modern city. The gas stations are situated in compliance with the regulatory and technical requirements, as a rule, based on terms of their ecological and environmental safety. However, gas stations are located in close proximity to residential habitation’s buildings. These gas stations are sources of pollution of the atmosphere of urbanized areas obviously. At the same time, the normative dimensions’ values of the sanitary protection zone are not allowed to decrease. In this case gas stations exert a negative impact on the residential habitation’s areas of the cities. It was determined maximum one-time and gross annual average emissions’ volumes from gas stations using of current calculating methods. It is found that the maximum emissions of ingredients are preceded for the filling draining gasoline from road tanker trucks to storage tanks. It was having been fulfilled experimental studies to determine the concentrations of hydrocarbon vapors in residential buildings in the areas of gas stations in Stavropol and Volgograd. It reveals exceeds acceptable concentrations’ limit of pollutants for mention above technical operation of in the air at the border of the SPZ of filling stations and residential buildings. Analysis of the data of the calculation monitoring showed the same that field studies. The most promising for reducing gas vapor emissions’ was applying absorptive device for trapping gasoline vapors in industrial set up. The high efficiency of gas vapors capturing in the proposed absorptive apparatus was confirmed by successful test of industrial set up.

1. Introduction
The design, work and maintenance focuses of gas filling stations (GFS) are ensuring their fire and explosion safety due to the specifics of their technological processes associated with receiving, storing and dispensing operations of gas and gasoline fuels. The number of GFS is growing up and volumes of fuel sales increase every year in the Russian Federation. Often gas filling stations are situated within compact population residing of development of urban structures. [1-6]. Growing up emissions’ volumes of gas vapor ingredients that exhaust into atmosphere from GFS and simultaneously of urban every day are being increasing for present time both. At the same time the results of calculations of volume emissions of pollutants exhausting into the city's atmosphere from out the only average GFS could reach up to 9.9 tons per year [3,4]. Xylene and toluene are most harmful and dangerous
components of the gasoline vapor. The measurements’ results of the concentrations of these harmful substances in the air at the border of the residential building that are located within the sanitary protection zone (SPZ) of the GFS showed that it exceed the allowable values around up to 2-3 times more due to maximum permissible concentration $C_{mpc}$. [3, 7, 8]. This is occurred and observed when gas fuel drains from the fuel filling tanks’ trucks into the storage tanks of GFS. There were presented and outlined the real acceptable ways for decreasing the emissions’ volume of harmful vapor ingredients into the atmosphere exhausting GFS, for example, in [3, 7-12]. There were presented results of study of the hydrodynamic operating modes of the apparatus for capturing vapors of heavy oil hydrocarbons’ ingredients in [8-12]. Evaluation of solid particles slippage’ amount throw out wet dust cleaning devices and dust capturing in tray – bulk scrubbers in the dust removal devices system in scientific focus of study too, for example. [13-15]. One of the aims of presented research is to determine real levels of pollution of the atmosphere within the residential urbanized habitation’s areas of the city where GFS are situated. Also the essential aim of our study is testing such approach to decrease harmful vapor volume of the emissions really acceptable.

2. Materials and methods of research

GFS are highly integrated part of the urban economy and the municipal life of the modern city. The location of the GFS, as a rule, is carried out in compliance with the state laws regulations and technical requirements to provide their ecological technical and environmental safety. However, GFS are located in close proximity and within the urbanized residential habitation’s buildings zones of the cities and are sources of pollution of the atmosphere of the urbanized areas. At the same time, the normative dimensions of the sanitary protection zone (SPZ) are not allowed to decrease. It means that a negative GFS impact factor on the residential habitation’s buildings areas of cities exist. Pollution of the air cities increases too. It was determined maximum-one-time and gross amount volumes of emissions into the atmosphere using current calculation methods. It was founded that the maximum emissions of ingredients are accompanied by the processes of draining gasoline from road tanker trucks to storage tanks. It was fulfilled experimental studies to determine the concentrations of hydrocarbons’ vapors in the atmosphere in residential buildings in the GFS situated areas in Stavropol and Volgograd. It was allowed to evaluate actual level of atmospheric pollution by oil product hydrocarbons’ vapors. The obtained and performed results of field measurements and in the work showed that there are exceed levels of pollutants’ concentrations in the air at the border of the SPZ of filling stations and residential buildings during the discharge of gasoline from road tankers.

Preliminary steps to get the actual level of atmospheric pollution and quality of atmospheric air in the areas where GFS are located in the city of Stavropol were carried out accordingly following activities:

- it was made analysis of planning decisions and peculiarities of the location of GFS in urban residential habitation’s buildings zones;
- it was revelled determining factors the degree of air pollution within residential buildings areas by oil benzene vapor during the operation of GFS are identified;
- it was determined the actual level of air pollution in residential buildings for proceeding operation with petrol benzene of the GFS;
- it was calculated the mass emissions’ volume of petrol benzene vapor exhausting into the atmosphere’s city from the GFS and the meanings of concentrations respectively caused by one’s.

Economic efficiency determines the choice of the location of the GFS, i.e. cross-country ability. According to tank’ productivity parameter that is equal number of tank’ volumes to be filled per day, all Stavropol GFS could be divided into 3 groups. The characteristics of Stavropol GFS are presented in table. 1.
Table 1. Classification of gas stations in the city of Stavropol, depending on the productivity parameter.

| Productivity parameter | Daily consumption of fuel, m³ per day | Annual consumption of fuel (average per year), m³ per year |
|------------------------|---------------------------------------|------------------------------------------------------------|
|                        | spring-summer period                  | autumn-winter period                                       |
|                        | petrol benzene                        | petrol benzene                                             |
|                        | diesel fuel                           | diesel fuel                                                |
| High                   | 50–65                                 | 19.5                                                      |
|                        |                                        | 6.8                                                       |
|                        |                                        | 5292.5                                                    |
|                        |                                        | 1825                                                      |
|                        |                                        | 3546                                                      |
| Medium                 | 30–50                                 | 12.6                                                      |
|                        |                                        | 4.7                                                       |
|                        |                                        | 3285                                                      |
|                        |                                        | 1241                                                      |
|                        |                                        | 2299.5                                                    |
|                        |                                        | 857.5                                                    |
| Low                    | 20–30                                 | 4.2                                                       |
|                        |                                        | 1.3                                                       |
|                        |                                        | 1606.2                                                    |
|                        |                                        | 365                                                       |
|                        |                                        | 1044                                                      |
|                        |                                        | 219                                                       |

The dimension of the SPZ of the gas station is set at 50 or 100 meters according to the existing sanitary standards, depending on the kind of fuel and the ability to fill diesel trucks. It was observed more than 100 GFS that were located within the residential habitation’s buildings areas. All Stavropol GFS were divided into 4 groups; each one’s is characterized the distance to close residential habitation’s buildings area, their range and principal direction of ground-level surface wind. Also specific these groups’ characteristics depend on other objects with permanent or temporary presence of service personal of stations and the kind of adjacent objects.

Climatic features of the terrain and structure habitation’s buildings are the important reasons formatting feature of stagnation gassed zones. At the same time, the habitation’s buildings development of Stavropol determines the possibility of forming distinctive wind corridors, within which the prevailing wind directions and velocities coincide with the wind vanes defined at the height. So that in such zones it is recommended placement of these facilities that are sources of emissions into the atmosphere.

Preliminary evaluation of GFS’ placement shows that more than 25% of these facilities are situated in the areas of wind calm in Stavropol. Such objection format stagnation gassed zones mention above around GFS facilities.

The emissions from the GFS sources depends on GFS preceded technological operations. Emissions have the maximum values when gas fuel drains from road tanks’ trucks and leaks into the storage tanks of GFS. The emissions of pollutants from GFS storage tanks (“big and small storage tanks’ breathing”) were calculated using topical techniques [16-17].

The points at which hydrocarbon concentrations were measured in control points at the industrial border, boundary of the SPZ and border of habitation’s buildings development that is located within SPZ in ground-level (2 m high). The choice of measuring points was determined by location of GFS facilities, other objects and nature wind direction. It was made at least 3 measurements at each point (from 10 to 30 numbers close and around GFS facilities). The measurements were carried out at an air temperature from 17 to 28 °C and a wind speed $u$ of the in choosing direction from 0.5 up to 6 m/s. The maximum value of the ground-level summary harmful hydrocarbons’ vapors of concentration is reached as a rule for $u = 0.5$ m/s and $u = 6$ m/s. It named as the dangerous velocity of wind.

The experimental measurements were carried out in accordance with accepted standard methods.

The air temperatures were measured using liquid alcohol, mercury thermometers, as well as thermo anemometers TA-4 LIOT and TA-8M also. The wind velocities were measured by wing and cup anemometers (models ASO-3 and MC-13 correlatively). The wind velocities were measured using thermo-anemometers at low wind velocities’ value.
Measurements of pollutant concentrations were fulfilled by gas analyzers model UG-2. Sampling of polluted air was carried out using glass syringes, as well as using special gas pipettes for the nature measured fields tests. Laboratory gas chromatographs (model "Color-100M" series) were used for the testing of samples [18].

The calculation method the emissions' dispersion of harmful (polluting) substances in atmospheric air from sources, including GFS, was applied by the methodic [16]. The maximum value of the ground-level concentration of harmful substances in exhausting gas-air mixture from a single point source with a circular wellhead is reached under unfavorable meteorological conditions for mention above technological operations.

3. Results

Maximum values summary harmful hydrocarbons' vapors ground-level concentration in atmospheric air is shown at the table 2.

**Table 2.** Values of maximum ground-level summary concentration hydrocarbons’ vapors in atmospheric air.

| Technological operations GFS | Summary values concentration hydrocarbons’ vapors $C_{v}$, mg/m$^3$ for wind velocity $u_{w}$, m/s |
|-----------------------------|--------------------------------------------------|
|                             | 0.5  | 2    | 5    |
| Fueling in the tank of one car | 75.46| 30.184 | 11.79 |
| Simultaneous filling of four cars with fuel of different kinds of benzene fuel | 224.646 | 89.858 | 35.1 |
| Simultaneous filling of eight cars | 449.29 | 179.7 | 70.2 |
| Drain benzene fuel into one storage tank from road tank’ truck | 4055.98 | 1622.39 | 633.5 |
| Simultaneous drain benzene fuel from road tanks’ trucks and leaks into two storage tanks | 8111.45 | 3244.6 | 1267.4 |

The summary hydrocarbons’ vapors ground-level concentration of harmful substances for dangerous wind’ velocity in atmospheric air along the axis of the ejection flare is determined at various distances x (m) from the emission source (GFS). The calculated values of ground-level concentrations at a distance of 10, 30, 50 and 100 meters from the source for different technological operations GFS are given in table 3.

**Table 3.** Summary values of ground-level hydrocarbons’ concentrations in atmospheric air at various distances from the source GFS.

| Technological operations in GFS | Distance from the GFS facilities source, m |
|--------------------------------|------------------------------------------|
|                               | 10    | 30    | 50    | 100   |
| Fueling in the tank of one car | 27.45  | 2.59  | 1.03  | 0.27  |
| Simultaneous filling of four cars with fuel of different kinds of benzene fuel | 81.77  | 7.64  | 3.078 | 0.84  |
| Simultaneous filling of eight cars | 163.54 | 15.28 | 6.16  | 1.61  |
| Drain benzene fuel into one storage tank from road tank’ truck | 1478.4 | 137.9 | 55.57 | 14.52 |
| Simultaneous drain benzene fuel from road tanks’ trucks and leaks into two storage tanks | 2954.57 | 275.79 | 111.13 | 29.01 |
Summary values of ground-level vapor benzene concentrations in atmospheric air was fulfilled by the field measurements in areas where were situated GFS facilities. The evaluation of the actual air pollution by benzene containing hydrocarbons is shown in table 4.

**Table 4.** Results of measurement of summary ground-level vapor benzene concentrations in atmospheric air around placement areas of GFS facilities in Stavropol.

| № measure points | Benzene concentrations in atmosphere, $C_s$, mg/m$^3$ | Comment | № measure points | Benzene concentrations in atmosphere, $C_s$, mg/m$^3$ | Comment |
|------------------|-----------------------------------------------|---------|------------------|-----------------------------------------------|---------|
| 1                | 2-6                                           | refueling 2 cars | 9                | 6-45                                          | 3-7     |
| 2                | 3-10                                          | refueling 2 cars | 10               | 7-52                                          | 2-5     |
|                  | 11-32                                         | refueling 8 cars |                  |                                               |         |
| 3                | 5-8                                           | refueling 8 cars | 11               | 4-14                                          | 3,4     |
| 4                | 3-10                                          | for the moment of drain fuel from the road tank’ trucks | 12               | 9                                             | 3       |
|                  | 20-132                                        | for the moment of drain fuel from the road tank’ trucks and refueling cars | 13               | 16                                            | 3       |
|                  | 5-12                                         | for the moment of drain fuel from the road tank’ trucks |                  |                                               |         |
| 6                | 18-148                                        | for the moment of drain fuel from the road tank’ trucks and refueling cars | 14               | 14,3                                          | 2       |
|                  | 4-16                                         | for the moment of drain fuel from the road tank’ trucks and refueling cars |                  |                                               |         |
| 7                | 22-185                                        | for the moment of drain fuel from the road tank’ trucks and refueling cars | 15               | 5                                             | 3       |
|                  | 4-18                                         | for the moment of drain fuel from the road tank’ trucks and refueling cars |                  |                                               |         |
| 8                | 18-192                                        | for the moment of drain fuel from the road tank’ trucks and refueling cars | 16               | 4                                             | 3       |
|                  | 5-23                                         | for the moment of drain fuel from the road tank’ trucks and refueling cars |                  |                                               |         |

There is showed the averaged results for the ground-level vapor concentrations harmful (polluting) substances in atmospheric air around placement areas of GFS facilities that were tested in Stavropol for a height of emission source $H = 5$ m in the figure 1. There is shows the averaged results ground-level vapor concentrations harmful (polluting) substances in atmospheric air around placement areas of GFS facilities that were tested in Stavropol for an accepted actual height of emission source $H = 3$ m in the figure 2. The graphs and are given for some emission ingredients for which the It was observed discrepancy between the measured and the calculated values of the concentrations was significant (maximum) for some harmful substances (xylene, code 602 and toluene, code 616) in atmospheric air.

The graphs was plotted at figures 1 and figures 2 show the results of modeling the dispersion of pollutant emissions and the averaged values of the measured concentrations of the ingredients in the atmosphere in areas of GFS facilities’ location in Stavropol where study was of that were fulfilled.
The related to $C_{MPC}$ values of the calculated and measured ground-level concentrations in atmospheric air of xylene (602) ($C_i/C_{MPC}$) and toluene (C616) ($C_i/C_{MPC}$) for the height of the unorganized source of GFS facilities’ for a height of emission source $H = 5$ m (recommended for calculation).

The following conditional abbreviations are accepted at the plots that were shown at the fig. 1 and fig.2. ACC - average concentrations of calculated ingredients. These concentrations of ingredients hydrocarbons were calculated, obtained by calculation according to the program Eco-Center (based were calculated using topical techniques [16-17, 19]. ACM - mean concentrations measured (according to measurements).

At the same time, the average values of the measured concentrations of the ingredients (ACM) of xylene (602) and toluene (C616) were calculated from the total summary measured values of
hydrocarbon concentrations on the basis of their content in a gasoline vapor mixture accordingly regulation and normative documents.

4. Conclusion
The presence of residential habitation’s buildings development within the boundaries of the GFS facilities’ SPZ and ground-level vapor benzene hydrocarbons ingredients concentrations in atmospheric air exceeded the values $C_{MPC}$ in the control points that are located in buildings development’ border should suggest environmental protect activity. It means that complex of environmental measures to reduce pollutant emissions into the atmosphere from GFS facilities need to realize. Technological environmental protect measures, for example, excluding the simultaneous drain of fuel from two tanker tankers, do not provide a reduction in the concentrations of gasoline hydrocarbons at the SPZ boundary and habitation’s buildings development (Fig. 1 and Fig. 2). At the same time, it is advisable to install a system with devices for trapping hydrocarbon vapors, for example, using proposed device design, for instance, in [20]. It could be applied for GFS facilities, where residential buildings developments are situated within the SPZ boundary. Proposed device [20] allows getting significant reduction in the volumes of pollutant benzene hydrocarbons ingredients’ emissions exhausting from GFS facilities into the atmosphere around in an average of 90%.

5. References
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