Analysis of Methods for Determining Emissions from Oil Storage in Russia and the United States

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Abstract. There are different approaches to the standardizing of hydrocarbons’ emissions in Russia and the USA. In Russia there are levels of techniques of vaporizations’ determination, of ecological standards of emissions, there are norms of natural losses. In the USA the technique is identical at different services. The Russian techniques are much like to American. Some differences and uncertainties in the emissions’ determination by different techniques are presented in the paper.

1. Introduction

In the USA the main document in the sphere of air protection is "The Clean Air Act". «The Clean Air Act" is a federal law of the United States where legal reasons of emission control from stationary and mobile sources are stated. Initially the law was adopted in 1963 and significantly amended in 1970, 1977 and 1990.

According to this law the Environmental Protection Agency (EPA) controls emissions. The enterprises of the USA are obliged to submit annually the reports on emissions of these substances (Toxic Chemical Release Inventory Reporting Forms and Instructions).

The presented technique for the calculation of losses of hydrocarbons from evaporation from tanks with a stationary roof from the API MPMS 19-1 standard and a technique with a pontoon from the API MPMS 19-2 standard were developed for tanks by the American Petroleum Institute (American Petroleum Institute – API).

It should be noted that along with the standards of the American Petroleum Institute mentioned above there is a document of the Environmental Protection Agency EPA AP42 Compilation of Air Pollutant Emission Factors (the review of factors polluting air), (liquid storage tanks are tanks for storage of liquid products) just the same technique for the calculation of emissions in the atmosphere from tanks is presented in chapter 7, as well as it is given in the API MPMS 19-1 and API MPMS 19-2 standards.

If to consider Russia, the situation is different. There are techniques of emissions’ determination which ecologists apply, for example, at assessment of impact on air from the existing or designed projects and also the techniques for the calculation of losses of hydrocarbons from evaporation were offered by certain authors: Konstantinov, Chernikin, Korshak, Abuzova, etc., at different times. These techniques are, as a rule, excessively filled with details and not adapted for the practical application, and, above all, not having the status of official normative documents. Thus, it is obvious that there is an obvious gap in this field in Russia. That is why there was a necessity to refer to the available international experience, to consider the American standards which have been already mentioned...
above: API MPMS 19-1, API MPMS 19-2 and to compare them to Konstantinov and Chernikin's techniques.

2. Results and discussion

Volumes of oil products’ consumption increase every year. It explains the oil production gain, and the development of the oil and gas industry. Consequently, it is necessary to increase volumes of storage of hydrocarbons annually. Losses from evaporation of oil products increase proportionally at increase in volumes of storage [1]. Now the methodical instructions developed in the 20th century are applied at emissions’ standardization in Russia and the USA. These techniques do not consider modern production conditions of reservoir parks and its equipment [2].

Emissions from evaporation of oil depend, first of all, on properties of oil product, a geographical location, and the tank. The whole territory of Russia is divided into three types (figure 1), 1 - the North and adjacent areas, 2 - regions of a temperate climate, 3 - areas with hot climate [3]. The norms of natural losses are characteristic of every type. Temperature influences on emissions more, so in hot areas the amount of evaporation is 10 times higher than in the north. There are norms of natural losses describing the loss of oil products in the course of storage, and transportation.

Carrying out calculations of evaporations, it was noticed by authors, that some coefficients do not transform the accuracy at measurements. Observations were made to prove this fact, and the author defined that for each product, the coefficient which is responsible for qualitative characteristics of the tank will be different as each product has the physical and chemical properties which are not considered when calculating this coefficient [4].

First of all, evaporations depend on structural imperfection. In the long term, the development of the industry will reduce this factor to a minimum [5].

Today there are several main methods of calculation of oil evaporations in the world; each method contains factors which are not considered in modern norms. To see why, each technique was looked closely in the paper, namely: N.N, Konstantinov, V.I. Chernikin's technique, technique of the American Petroleum Institute [6].

Figure 1. The distribution of territorial subjects of the Russian Federation by climatic groups.
2.1. Methodology of N.N. Konstantinov and V.I. Chernikin

In the Konstantinov-Chernikin methodology, the number of evaporations depends on the intensity of the solar radiation. Cloudiness and other factors are poorly predictable, so the actual amount of emissions may differ significantly from the calculated one.

The calculated sun declination $\varphi$ will be found by the formula:

$$\varphi = -23.0 + 1.39 \cdot 10^{-2} (365 - N_{DAY})^{2.12},$$  \hspace{1cm} (1)

The day length $\tau_{dn}$ is calculated by the formula:

$$\tau_{day} = \frac{2}{15} \arccos(-\frac{\text{tg}\varphi \cdot \text{tg}\psi}{\text{tg}\psi + \varphi}),$$ \hspace{1cm} (2)

Let us determine the intensity of the solar radiation without taking into account the cloudiness $I_0$ by the formula:

$$I_0 = \frac{1357 \cdot K_0}{1 + \frac{1 - \gamma}{\gamma \cdot \cos(\psi - \varphi)}},$$ \hspace{1cm} (3)

where $\gamma$ - is the atmospheric transmittance coefficient

At the moment, the methodology does not meet current standards for calculating the evaporation. It is complicated by calculations of uncontrolled natural phenomena.

2.2. Methodology of the American Petroleum Institute

The third edition of API MPMS 19.1 (2002) (A Collection of Standards for Measurement in the Oil Industry of the American Petroleum Institute, Chapter 19, Section 1) presents a methodology for estimating the total losses due to evaporation or equivalent hydrocarbon emissions into the atmosphere from fixed-roof tanks for storing multi-component hydrocarbons (such as liquid hydrocarbons, for example, crude oil) or single-component hydrocarbons (such as petrochemical feedstock, for example, ethanol). The formula for calculating evaporation losses during storage (no working operations in the tank) was improved in the second edition of API 2518 (also known as API Manual of Petroleum Measurement Standards, Chapter 19.1 (API MPMS 19.1)) compared to that used in the first API 2518 edition. The formula for determining the evaporation losses due to working operations in the second edition of API 2518 remains the same as in the first one. In the third edition, the same calculation formulas are used as in the second one, but as additional information, there is provided the simplified procedure for calculating the evaporation losses [10, 11].

Total evaporation loss, $L_T$

Total evaporation losses, $L_T$ (pounds per year) consist of evaporation losses during storage (no working operations in the tank) and losses due to operation (filling the tank and pumping out the product):

$$L_T = L_S + L_W,$$ \hspace{1cm} (4)

where $L_S$ – is the loss of product from evaporation during storage (pounds per year);

$L_W$ – product losses due to evaporation during operation: filling and pumping out (pounds per year).

Evaporation losses during the storage $L_S$

The following information is required for the calculation of losses at $L_S$ storage:

• the diameter of the tank;
• the tank wall height;
• the tank roof type (cone-shaped or dome);
• the color of an external surface;
• the location of the tank;
• the type of a product;
• the bulk temperature of a product;
• the pressure of saturated steam of a product (or pressure of saturated steam of a product by Raid);
• the level of a liquid product.

The more exact loss estimate of a product at storage can be received if there are all or some of the following additional data:
• the deviation angle of a cone-shaped roof or radius of a dome roof;
• the adjustment of the respiratory valve by the pressure and vacuum;
• the average daily ambient temperature;
• the daily ambient temperature range;
• the general daily insolation on a horizontal surface;
• the atmospheric pressure;
• the molar mass of vapors of a product;
• the temperature of a surface of a liquid product.

Evaporation losses at storage (Ls) arise at breathing of steam space of the tank.

For the definition of losses from evaporation at storage the following formula is applied:

\[ L_s = 3.65 K_E H_{VO} \left( \frac{\pi}{4} D^2 \right) K_S W_V, \]

where \( K_E \) – the coefficient of expansion of steam-gas space (dimensionless size);
\( H_{VO} \) is free steam-gas space of the tank (in feet);
\( D \) – the internal diameter of the tank (in feet);
\( K_S \) – the coefficient of saturation of the emit steam (dimensionless size);
\( W_V \) is density of vapors of a product (in pounds on cubic foot);
\( 356 \) – the number of days in a year (dimension: year\(^{-1}\)).

The technique of the American Petroleum Institute includes the coefficient of losses from roof joints, tanks owing to operation are exposed to the deformation, therefore, this coefficient gains absolutely other values [7]. In total each of coefficients results in inaccuracies in calculation of emissions.

Table 1. Coefficients of a technique of the American Petroleum Institute.

| Formula | Value |
|---------|-------|
| C       | the sticking coefficient, depends on type of a product and the state of a wall of the tank (degree of corrosion) |
| Kra     | the coefficient depending on type of a design of the tank, the flap type |
| Kibi    | the coefficient of losses of roof fittings of a certain type depending on wind speed |
| Kfai    | the coefficient of losses from fittings of a roof of a certain type at a zero speed of wind |
| Kd      | the coefficient of losses from roof joints per unit joint length |
| Sd      | the roof joint length coefficient |

The technique of calculations of the American Petroleum Institute includes some points of calculations which are not realized in Russia because of the specific structure of tanks, separate details and elements of fasteners. It does not meet the standards approved in the Russian Federation [8, 9, and 10].

3. Conclusion
In the conclusion, it is worth mentioning that the oil and gas industry is one of key industries, therefore it is worth paying attention to the solution of problems in this sphere. And parallel to it it is active to
introduce new technologies in the industry as much as possible to reduce emissions of vapors of oil and oil products.

The development of modern structures and prevention ways of leaks is already now available. However more careful attention from the government is required and the management of companies in order that modern ways of prevention reached the most stations.

4. References
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