Influence of seasonal changes in climatic conditions on losses at oil tanks filling (on example of the Republic of Bashkortostan)

Alexey Elizaryev^{1,2*}, Dmitry Tarakanov¹, Sergey Aksenov¹, Denis Tarakanov¹, Elena Elizareva^{1,3}, Elina Nasyrova¹, and Airat Nazyrov⁴

¹ Ufa State Aviation Technical University, Karl Marx str.12, 450008, Ufa, Republic of Bashkortostan, Russia

² Water Problems Institute, Russian Academy of Sciences, Gubkina str.3, 119333, Moscow, Russia

³ Bashkir state University, Zaki Validi str.32, 450076, Ufa, Republic of Bashkortostan, Russia

⁴ Ufa State Oil Technical University, Kosmonavtov str. 1, 450062, Ufa, Republic of Bashkortostan, Russian Federation

Abstract. Research objective: determining the effect of Influence of seasonal changes on losses at oil tanks filling (on example of the Republic of Bashkortostan). There are many types of oil losses, but most of all is filling loss. They are polluting the environment on the territory of agricultural and oil facilities. They can lead to fire, explosion at oil storage facilities, agricultural enterprises. Method of research: filling loss directly depend on the daily temperature and atmospheric pressure. The work has worked out the values of temperature and atmospheric pressure for the year. Based on the obtained values of air temperature and atmospheric pressure, the volume of big breathing was calculated. Results of the study: the greatest environmental pollution is observed in the summer. In General, there is a uniform dynamics of changes in big breathing throughout the year on the entire territory of the Republic of Bashkortostan.

1 Introduction

The problem of petroleum products loss is gaining relevance in the modern world. This issue confirmed in the publications of many scientists [1-6]. Oil industry specialist try to reduce losses. The number of losses reaches 1.5% of all produced oil. During transportation, transfer and storage 75% of the expensive product is lost as a result of evaporation. The remaining 25% is lost in accidents and leakages. Filling loss (big breathing) accounting the majority of reservoir losses (more than 50%). This type of loss is occurs by ejecting air from the tank. The qualitative composition of air is saturated hydrocarbons. Ejections lead to environmental pollution and explosion situations. Every year occur more than 10 emergencies caused by loss of oil products. The main reasons are: wear and tear of equipment, opening of technical devices and violations in the operation of tank farms.

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* Corresponding author: elizariyev@mail.ru

Filling loss (big breathing) depends on climatic conditions and loading/discharge operations. The tank farm, agricultural facility can be located on the territory with high daily temperature difference and atmospheric pressure. Such conditions lead for changing of losses volume. Storage of oil and oil products takes place in tanks of various types and volumes. The most common tank in Russia and abroad is a vertical stainless steel tank with a capacity of 5,000 m³. He was chosen as the object of research.

Thus, the main task of work to study the influence of seasonal changes seasonal changes in climatic conditions on the filling loss dynamics (on the example of the Republic of Bashkortostan).

2 Materials and methods

At the moment, there are 3 most common methods for quantifying the volume of oil and petroleum products vapors from filling loss (big breathing) **Error! Reference source not found.-Error! Reference source not found.:**

Methodology of American Petroleum Institute **Error! Reference source not found..** Computer program «TANKS» based on this method was developed. It allows determining the volume of oil and petroleum products emissions from reservoirs. For calculating the average annual loss from filling loss, the method suggests using the following formula (1):

$$L_w = NH_{LX} \left(\frac{\pi}{4} D^2 \right) \cdot K_N \cdot K_p \cdot K_B \cdot W_V \quad (1)$$

where N – the rate of turnover of product, rpm/year;

H_{LX} – maximum liquid product level in the tank, ft;

D – inner diameter of the tank, ft;

K_N – loss factor the product of the turnover;

K_p – the loss factor, depending on the type of product;

K_B – the correction factor for the configuration of the breather valve;

W_V – product vapor density, pound/ft³.

The Second method is in Chapter 6 of the German Association of engineer's guidance document VDI 3479 «Control of emissions from tank farms that are not located in oil processing areas» **Error! Reference source not found..** The document was created in accordance with the recommendations and requirements of the VDI 1000 **Error! Reference source not found..** The method **Error! Reference source not found.** was developed using data obtained from the General project of BMI and DGMK 4509-01 – 4590-12 **Error! Reference source not found..** For calculating the average annual loss from filling loss, the method suggests using the following formula (2):

$$L_{B,a} = f_B \cdot 12 \cdot 10^{-3} \cdot \frac{1}{T} \cdot p_T \cdot \bar{M} \cdot Q \quad (2)$$

where f_B – degree of saturation;

T – product temperature in the tank, K;

p_T – saturated vapor pressure of the product in the tank at the product temperature, hPa;

$\bar{M}$ – the average molar mass of hydrocarbons in the vapor-air space above the product in the reservoir, kg/kmol;

Q – amount of liquid poured per year, m³/year.

The methodology presented in the second edition of the textbook Chugunova P. I. and Novoselov V. F., "Model calculations for the design and operation of tank farms and oil pipelines» **Error! Reference source not found..** The authors of the second edition are A. A. Korshak and A. M. Shammazov. For calculating the volume of filling loss is carried out the formula (3):

$$G_{sb} = \left[V_H - V_{gs} \cdot \left(\frac{P_2 - P_1}{P_2 - P_{y \text{ pump}}} \right) \right] \cdot \frac{P_{y \text{ pump}}}{P_2} \cdot \rho_y \tag{3}$$

where V_H – volume of oil injected into the tank, m3;
 V_{gs} – the volume of the gas space in front of the oil pumping, m3;
 P_2 – absolute pressure in the gas space at the end of the injection, Pa;
 P_1 – absolute pressure in the gas space at the beginning of injection, Pa;
 $P_{y \text{ in}}$ – the estimated average partial pressure of oil vapor in the process of filling the tank, Pa;
 ρ_y – the density of oil vapor, kg/m3.

For comparative analysis of following methods were used data for vertical stainless steel tank with a capacity of 5,000 m3 (Table 1) and the same climatic conditions.

Table 1. Unified source data for calculation.

Parameter	Value
Inner diameter of the tank	22.8 m
Internal volume of the tank	4,864 m ³
Installation of breathing valves for overpressure	1,600 Pa
The installation of the breathing valves on the vacuum pressure	150 Pa
Radius of the mounting pipe	0.25 m
The number of respiratory valves	2
Oil product pumping rate	400 m ³ /h
Oil product injection rate	600 m ³ /h
Oil density	845.4 kg/m ³
The coefficient of volume expansion of the oil	0.000831 1/K
Average molar mass of product vapors	54 kg/kmol
Reduced height of take-off before pumping	7 m
Reduced takeoff height after pumping	5 m
Reduced height of take-off before injection	5 m
Reduced takeoff height after injection	9 m

The Republic of Bashkortostan lies in a temperate climate zone. The climate is characterized by low humidity, cold winters and warm summers. The variety of terrain, the presence of the Ural ridge, located in the direction of the Meridian, explain the significant differences in temperature and humidity on the territory of the Republic of Bashkortostan (Table 2). In this regard the average annual air temperature in the South-Western and Central regions is +2°C, +3°C, in the North-Eastern and mountainous regions 0°C, +1°C .

Table 2. Data on temperature and atmospheric pressure (for 2018 year).

Weather stations	Winter period		Spring period		Summer period		Autumn period	
	$t_{a,}$ °C	$P_{cp,}$ kPa	$t_{a,}$ °C	$P_{cp,}$ kPa	$t_{a,}$ °C	$P_{cp,}$ kPa	$t_{a,}$ °C	$P_{cp,}$ kPa
Yanaul	-11.8	101.6	1.1	100.3	17.1	100.3	4.1	100.7
Duvan	-12.6	98.6	0.9	97.4	16.0	97.2	2.8	97.8
Ufa	-11.4	101.6	2.3	100.3	18.3	99.9	4.5	100.7
Zilair	-13.5	96.5	1.8	95.4	17.1	95.2	3.0	95.9

When analyzing the dynamics of oil vapors due to big breaths, the reservoirs located in these areas are considered.

3 Results and discussion

Comparative analysis of the results of calculations using the methods [10,11,12] was performed (Fig. 1). Method [12] was taken as the standard. Method [12] uses a greater number of optional input parameters. This has a positive effect on the accuracy of the results.

Fig. 1. Comparative analysis of the results of calculating the volume of losses from filling loss by methods [10-12].

Comparative analysis in Fig. 1 showed a significant difference between the results of calculating the losses volume from filling by three methods. This is due to the amount of raw data. The losses calculated by the method [10] differ from the standard by more than 30%. Further using this method for the analysis of oil vapors volume from filling loss is impractical. The method of calculating the average annual losses affected the difference in the results of calculations using the methods [11] and [12]. In the first case, the calculation consists of losses sum as a result of individual operations. In the second case, the calculation is based on multiplying the volume of losses from one filling loss per day by the number of days per year. The most suitable method for performing the task is the method [12]. For calculation it uses the maximum and minimum temperatures per day. This plays a key role in analyzing the dynamics of losses.

Data on the temperature regime and the average monthly atmospheric pressure for 2018 from the weather stations Yanaul, Ufa, Zilair and Duvan (Table. 2) helped to perform the calculation of losses from big breathing (filling loss) in the considered areas in the winter, spring, summer and autumn climatic periods (Fig. 2).

Fig. 2 showed a significant difference between the volume of big breathing (filling loss) during the year in different regions of the Republic of Bashkortostan. The greatest losses from filling loss are observed in the summer (more than 3,000 kg per breath). They have the main share in the total volume of evaporation. It tells about the pollution of the environment to a greater extent in the summer. The value of winter losses is lower by more than 10%. The values of losses in the spring and autumn periods do not have a significant difference. The amount of loss from filling changes by about 6% every three months. Total volumes of filling loss in the territory of the considered areas have no fundamental differences (no more than 5%). Ufa city has the largest volume of total losses and, consequently, the highest environmental pollution. In general, the losses volume from big

breathing (filling loss) on the territory of considered areas for the same time periods have similar values. This indicates a uniform dynamics of change throughout the year on the entire territory of the Republic of Bashkortostan.

Fig.2. The value of filling loss (in kg) in the considered areas in different time.

4 Conclusion

The analysis of methodological approaches for the quantitative assessment of big breathing volume was carried out. Based on the obtained results was choosing a more suitable method. The calculation of the filling loss magnitude in the winter, spring, summer and autumn climatic periods for three regions was performed. The results showed a single trend of big breathing volume changes during year on the territory of the Republic of Bashkortostan. This indicates the greatest pollution of the environment during the summer period and increases the risk of fire and explosion hazardous situations.

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