ANALYSIS OF CAUSES OF OIL PRODUCT LOSSES IN STORAGE TANKS AND METHODS FOR THEIR REDUCTION

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Abstract: This scientific article analyzes the main causes of losses that occur in storage tanks during the storage of crude oil and petroleum products, as well as methods for reducing these losses. The study is based on existing scientific and technical literature, particularly classical sources devoted to evaporation losses of petroleum products. The article examines the processes of "small breathing" and "large breathing," changes in the volume of the gas phase, temperature fluctuations, and the influence of technological operations. Technical and organizational measures aimed at reducing losses are systematically presented.

Keywords: storage tank, petroleum products, evaporation losses, small breathing, large breathing, gas phase, reflector disk.

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Introduction

Losses occurring during the storage and processing of petroleum products represent an economically and environmentally significant problem. Especially in atmospheric-type storage tanks, considerable losses are observed as a result of product evaporation. Practical experience and scientific research indicate that these losses are directly related to the state of the gas phase inside the tank, temperature variations, and the intensity of technological operations [3].

Evaporation Losses of Petroleum Products in Storage Tanks

Evaporation losses occurring during the storage of petroleum products constitute an important technological and economic issue. Particularly in open or semi-closed tanks, as well as during the exchange of the gas phase through breathing and vent valves, a significant amount of light fractions is released into the atmosphere. These processes not only lead to product losses but also contribute to environmental pollution.

Evaporation losses of petroleum products in storage tanks can be expressed by the following general relationship [4]:

$$M = K \cdot V_g \cdot (P_s - P_a)$$

where **M** is the amount of loss due to evaporation (kg), representing the mass of petroleum product released into the atmosphere over a certain period of time [5];

K is the evaporation intensity coefficient, which depends on the tank design, physicochemical properties of the product, temperature, ventilation conditions, and other factors;

V_g is the volume of the gas phase inside the tank (m^3), which increases as the liquid level in the tank decreases;

P_s is the saturated vapor pressure of the petroleum product (Pa), primarily dependent on product composition and temperature;

P_a is the atmospheric pressure (Pa), characterizing ambient conditions.

This expression shows that the amount of evaporation loss is directly proportional to the gas phase volume and the difference between the saturated vapor pressure of the product and atmospheric pressure. Thus, the larger the gas phase volume in the tank, the greater the evaporation losses. Similarly, light petroleum products with high vapor pressure (for example, gasoline) evaporate much faster than heavier fractions, resulting in greater losses.

Therefore, in practice, technical and technological measures such as reducing the gas phase volume inside tanks, using floating roofs, improving breathing valves, and maintaining storage temperatures as low as possible are applied to reduce evaporation losses. These measures not only improve economic efficiency but also enhance environmental safety.

Main Causes of Petroleum Product Losses in Storage Tanks

Losses During the "Small Breathing" Process

Small breathing is associated with the expansion and contraction of the gas phase inside the tank due to temperature changes. This process mainly occurs under the influence of daily and seasonal temperature fluctuations. An increase in gas phase volume causes the vapor–air mixture to be released into the atmosphere through the breathing valve.

Scientific sources indicate that the larger the gas phase volume, the higher the losses due to small breathing. Therefore, operating tanks at the maximum possible filling level is an important factor in reducing evaporation losses.

Relationship for Small Breathing Losses

Evaporation losses during small breathing are mainly determined by daily or seasonal temperature changes inside the tank. As temperature rises, the gas phase expands, and part of the

vapor–air mixture is released into the atmosphere through breathing valves. The resulting losses can be determined using the following expression [6]:

$$M\_kn = C \cdot V\_g \cdot (dP\_s / dT) \cdot \Delta T$$

where **M_sb** is the evaporation loss during small breathing (kg), representing the mass of petroleum product released due to temperature fluctuations;

dP_s/dT is the derivative of saturated vapor pressure with respect to temperature, characterizing the evaporation ability of the product;

ΔT is the temperature fluctuation inside the tank (°C), determined by daily or seasonal temperature differences;

C is an empirical coefficient depending on tank design, valve performance, and storage conditions.

Losses During the "Large Breathing" Process

Large breathing occurs during filling or emptying of petroleum products in storage tanks. In this case, changes in product level cause forced exchange of the gas phase with the external environment. Losses during large breathing are usually significantly greater than those during small breathing. Short intervals between technological operations and frequent internal tank-to-tank transfers considerably increase large breathing losses.

Large breathing losses occur during tank filling or emptying operations. Changes in liquid volume compress or expand the gas phase inside the tank, releasing large volumes of vapor–air mixture into the atmosphere. These losses can be evaluated using the following expression [7]:

$$M\_bn = \rho\_v \cdot V\_out$$

where **M_lb** is the amount of loss during large breathing (kg);

ρ_v is the density of the vapor–air mixture (kg/m³), which depends on temperature and vapor concentration;

V_out is the volume of gas mixture released to the atmosphere (m³).

Effect of Gas Phase Volume and Temperature

The gas phase volume inside the tank is a key parameter determining evaporation intensity. As temperature increases, the saturated vapor pressure of petroleum products rises, intensifying evaporation. Therefore, losses are higher during summer periods and under strong solar radiation.

Effect of Ventilation and Fittings Condition

Malfunctions or loss of tightness in breathing and vent valves lead to excessive release of vapor–air mixtures. Regular inspection of valve technical condition is an essential requirement
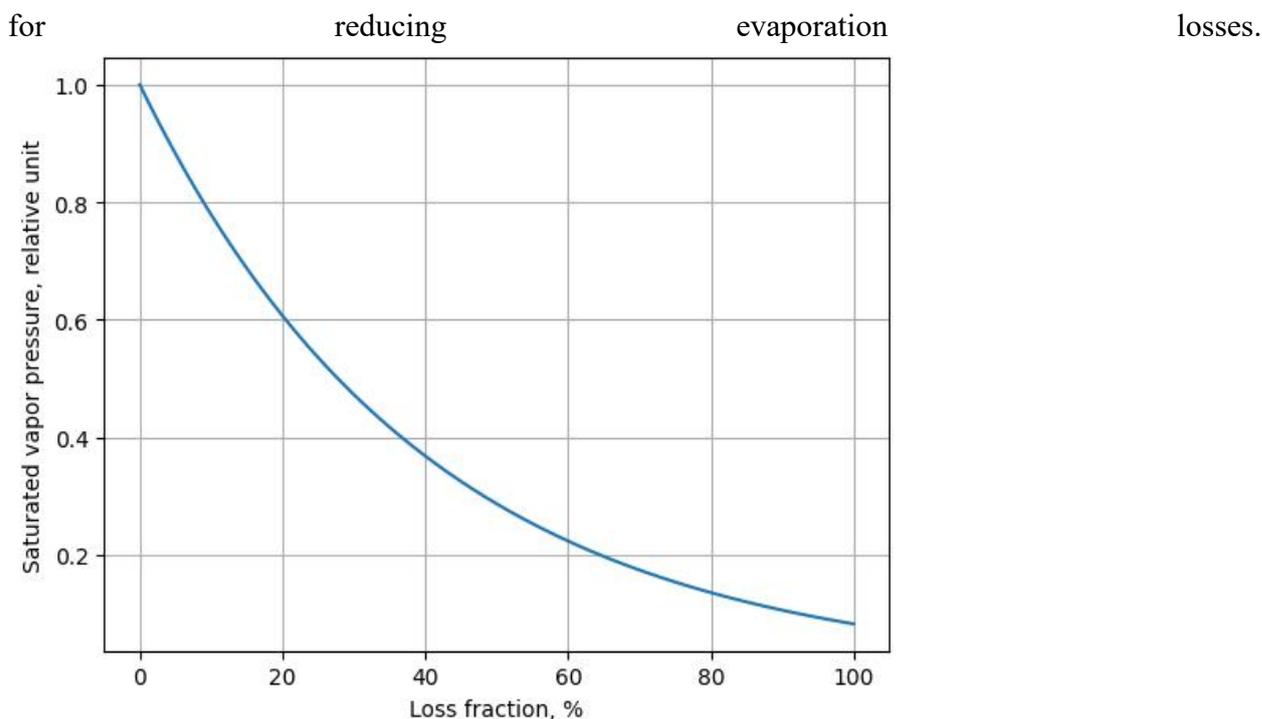
for   reducing   evaporation   losses.

Figure 1. Dependence of evaporation losses on saturated vapor pressure

Methods for Reducing Petroleum Product Losses
Reduction of Gas Phase Volume
Scientific research shows that minimizing gas phase volume significantly reduces evaporation losses. This method is implemented by using floating-roof or pontoon-type storage tanks.

Use of Deflector Disks
Deflector disks installed under breathing valves change the direction of incoming and outgoing airflows, reducing the effect of forced convection. Practical calculations show that these devices can reduce large breathing losses by 20–25% [8,9,11].
The efficiency of deflector disks depends on the following factors:
- disk diameter **D**;
- installation height **h**;
- mounting pipe diameter **d**.

Maximum efficiency is observed at ratios **h ≈ 2d** and **D ≈ (3–3.5)d**.

Gas Capture and Recovery Systems
Using gas equalization pipelines and gas collectors allows vapor–air mixtures to be redirected back into the technological process instead of being released into the atmosphere. This method is particularly effective in reducing large breathing losses.

To reduce evaporation losses, deflector disks are installed in storage tanks. These devices restrict the direct rise of vapors from the liquid surface, significantly reducing the amount of vapor released into the atmosphere. The reduction in losses after installing a deflector disk can be estimated using the following expression:

$$M' = M \cdot (1 - \eta)$$

where **M'** is the reduced loss after installing the deflector disk (kg);

M is the initial loss without a deflector disk (kg);

η is the efficiency coefficient of the deflector disk, typically taken as 0.2–0.25 in practice.

Using these relationships makes it possible to more accurately assess evaporation losses in storage tanks and develop effective technical solutions for their reduction.

Organizational and Technical Measures

The following organizational measures are important during tank operation:

- minimization of internal tank-to-tank transfers;
- maintaining maximum filling levels;
- coordination of technological operations;
- improvement of measurement and control systems.

Table 1. Causes of losses in storage tanks and methods for their reduction

Cause of loss	Main factor	Reduction method
Small breathing	Temperature fluctuation	Gas phase reduction
Large breathing	Filling/emptying	Deflector disk, gas piping
Ventilation losses	Valve malfunction	Technical inspection
Evaporation intensity	High temperature	Reflective coating, insulation

Conclusion

The analysis shows that petroleum product losses in storage tanks are a complex and multifactorial process closely related to gas phase conditions, temperature, and technological operations. To reduce losses, it is necessary to apply constructive, technical, and organizational measures in an integrated manner. The research results are of practical significance for reducing evaporation losses in oil depots and storage facilities.

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