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Practical Study of VOCs Emission from External Floating Roof Tanks

Zareie, S., Mowla*, D. and Fathi, J.
Chemical and Petroleum Engineering Department
Shiraz University
Shiraz- Iran

Abstract

Volatile organic compounds (VOCs) emitted from storage facilities play a key role in forming ground-level ozone, which causes breathing problems for humans and damages plants. In this paper, the amount of the Volatile Organic Compounds (VOCs) which is emitted from an industrial external floating roof tank is estimated practically and also by using the relations which are proposed by American Petroleum Institute (API). For this purpose the level of the considered liquid in the tank and its temperature are monitored and recorded for a period of 35 days. Comparison of the obtained practical data with those predicted by API relations under the same operating, geographical and meteorological conditions, shows that the practical data are higher than predicted values. These results in those same actions should be measured to lower the rate of emission of VOCs from the tank by improving the seals or considering the problem of seepage from the tank.

Keywords: VOC; External floating roof tank; Emission

Introduction

Storage vessels containing organic liquids can be found in many industries, including (1) petroleum producing and refining, (2) petrochemical and chemical manufacturing, (3) bulk storage and transfer operations, and (4) other industries consuming or producing organic liquids [1]. External floating-roof tanks are a major source of VOC emissions. Wind passing over the fittings that penetrate the tank roof cause product to evaporate from the surface of the tank [2].

External floating-roof tank (Fig. 1), consists of an open-topped cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid, rising and falling with the liquid level in the tank. A seal system is attached to the roof perimeter: it slides against the tank wall as the roof is raised and lowered. The seal system fills the annular space between the rim and the tank shell and therefore minimize evaporative losses from this area. The floating roof is equipped with operational fittings that penetrate the roof. The external floating-roof design is such that evaporative losses from the stored liquid are limited to losses from the seal system, roof fittings and any exposed liquid on the tank walls above the roof [2].

Emissions from storage tanks are usually estimated using the semi-empirical methodologies developed by the American Petroleum Institute. The data used for these estimates include such variables as the average liquid temperature, the average daily incident solar radiation and wind speed, and factors relating to the physical tank structure [3].

* Corresponding author
dmowla@shirazu.ac.ir
Fax 98-711-6281548

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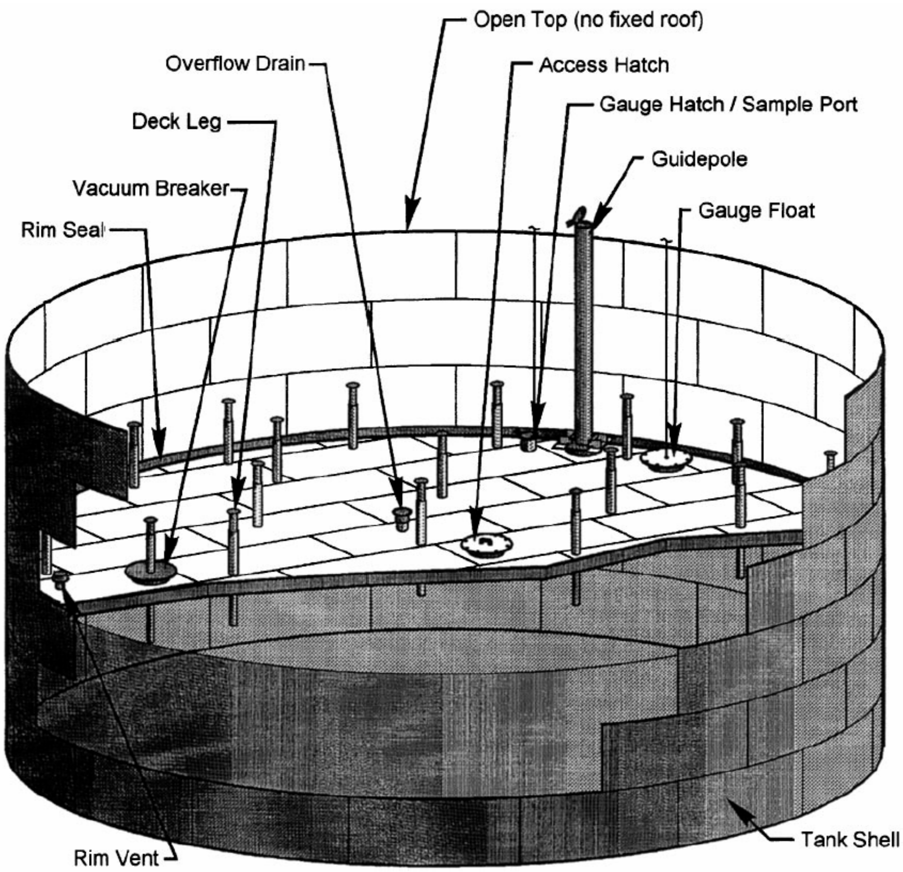

Fig.1. External floating-roof tank [2]

Main Results

The tank that is selected for monitoring, is a tank 16.630 m in diameter and 14.640 m in height, containing a liquid with specific gravity and Reid vapor pressure of 0.689 and 9 psi respectively. The level of the liquid in the tank and its temperature were measured and recorded with time. The reference temperature was kept as 60ºF and all measured volumes are converted to 60ºF conditions. The obtained practical results are shown in Table 1 and on Figure 2. According to these data, the average daily loss for this case was 1219.7 lit/day.

Table1. Measured data

Date of Measurements	Liquid Level m	Liquid Temperature ºF
25/5/2006	13.450	80.6
30/5/2006	13.386	84.2
1/6/2006	13.380	84.2
8/6/2006	13.332	80.6
15/6/2006	13.340	85.1
18/6/2006	13.338	86.9
22/6/2006	13.332	87.8
29/6/2006	13.324	87.8

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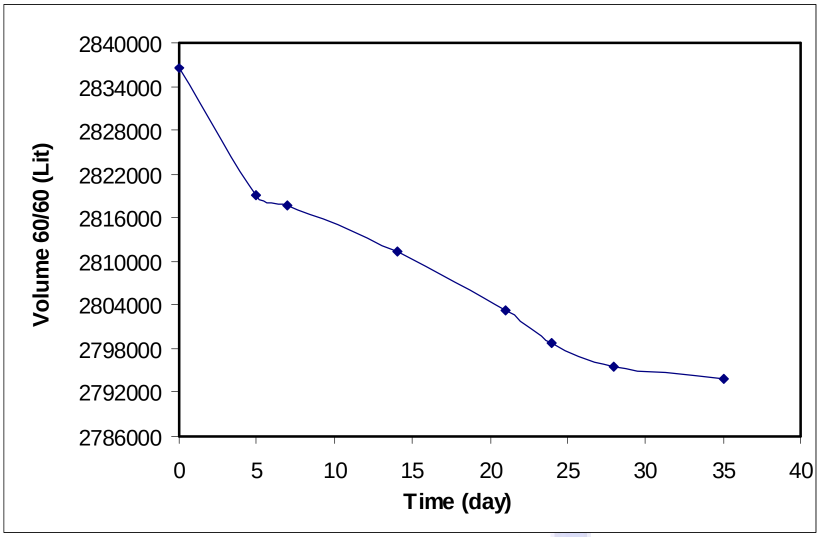

Fig.2. Volume of liquid in the tank versus time

The most famous relation for VOCs emissions from floating roof tanks is that proposed by API which is the form of:

$$L_T = L_R + L_{WD} + L_F + L_D \tag{1}$$

Where:

L_T = total loss, lb/year
L_R = rim seal loss, lb/ year; giving by Equation 2
L_{WD} = withdrawal loss, lb/ year, giving by Equation 3
L_F = deck fitting loss, lb/ year; giving by Equation 4
L_D = deck seam loss (internal floating roof tanks only), lb/year; giving by Equation 5

$$L_R = (K_{Ra} + K_{Rb} v^n) D P^* M_V K_C \tag{2}$$

$$L_{WD} = \frac{(0.934) Q C W_L}{D} \left[1 + \frac{N_C F_C}{D} \right] \tag{3}$$

$$L_F = F_F P^* M_V K_C \tag{4}$$

$$L_D = K_D S_D D^2 P^* M_V K_C \tag{5}$$

All of the parameters given in these equations are defined as follow and given in reference [1].

K_{Ra} = zero wind speed rim seal loss factor, lb-mole/ft year
K_{Rb} = wind speed dependent rim seal loss factor, lb-mole/(mph)^{n}ft year
v = average ambient wind speed at tank site, mph
n = seal-related wind speed exponent, dimensionless
P* = vapor pressure function, dimensionless
D = tank diameter, ft

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M_V = average vapor molecular weight, lb/lb-mole
K_C = product factor; K_C = 0.4 for crude oils; K_C = 1 for all other organic liquids.
Q = annual throughput (tank capacity [bbl] times annual turnover rate), bbl/year
C = shell clingage factor, bbl/1,000 ft^2
W_L = average organic liquid density, lb/gal
D = tank diameter, ft
0.943 = constant, 1,000 ft^3 gal/bbl^2
N_C = number of fixed roof support columns, dimensionless
F_C = effective column diameter, ft (column perimeter ft/π)
F_F = total deck fitting loss factor, lb-mole/year
K_D = deck seam loss per unit seam length factor, lb-mole/ft-year
S_D = deck seam length factor, ft/ft2

Using the operating, geographical and meteorological conditions applied to the studied tank will result in:

L_{WD} = 112.1 lb/year = 73.8 lit/year
L_R = 7769.8 lb/year = 5117.4 lit/year
L_F = 25568 lb/year = 16839.7 lit/year
L_T = 33449.9 lb/year = 22030.9 lit/year = 60.3 lit/day

Conclusion

Comparison of the results obtained practically for an average daily loss or emission of VOCs or 1219.7 lit/day for the considered tank with those obtained by API relations, namely 60.3 lit/day shows that there is a big difference between these data and so it is clear that the tank under consideration is operating at abnormal conditions from the emission point of view. It means that either the sealing and the fittings of this tank are damaged or there is a problem of seepage for this tank. This method reveals an easy method for verifying the situation of floating roof tanks with standard conditions.

References

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