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# Evaluation of Some Oil, Gasoline and Condensate Losses in Tank Cars Transport


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## Abstract

*The paper presents the results obtained in the research carried out for the evaluation of oil, gasoline and condensate losses when transporting them to the beneficiaries by means of tank cars.*



**Key words:** tank car, loss, oil, gasoline, condensate


## Introduction

The paper represents the result of a research paper for SC Conpet SA carried out for the evaluation of oil, gasoline and condensate losses occurred during their being transported to the beneficiaries by means of tank cars.

The results obtained are based on the calculation technology put forward by the authors of the papers.

## Gasoline, condensate and ethane losses

As a rule, the tank that reached the loading ramp must be pressurised at the same pressure value as that at the end of the previous discharge. In reality, the pressure in the tank at the beginning of its loading with gasoline is comprised between 7 and 12 bar and, in some situations, it is even atmospheric. Under these conditions, the first quantities of gasoline that reach the tank are used to regenerate its “stock” that can be considered lost, at least partially, at each filling-up operation. The pressure in the tank after it has been filled up is 18 bar, similar to the pressure in the delivery tank.

At the unloading ramp, there can be noticed that the pressure in the tank falls between 12 and 14 bar, therefore a large part of the product was lost during transport, due to the lack of tightness of the reinforcement of the tank. At the end of the tank’s discharge operation, the valves on the tank are closed, as well as those on the pipe that connects it with the storage tank and the gasoline left on the drainage hose, which cannot be recovered, shall be evacuated in the air. It is to be noticed the fact that, unlike the oil leaks from ramps that can partially be recovered, gasoline, ethane or condensate leaks are lost completely.

## Oil losses

### The causes of oil losses in railroad transport

During the loading of the tank, there occur high losses due to evaporation, because the distance between the end of the feeding hole and the free surface of the liquid is relatively big; the ramps in Conpet do not have filling devices with telescopic loading pipe and test indicator that could keep an appropriate distance between the outlet hole of the oil and the free area during the entire filling-up period.

Other losses at the filling-up of the tanks occur by splashing, by drainage when manipulating the funnels that are used at the pouring gate of the tank, as well as by the accidental overflowing of oil from the tank when the prescribed filling level is not carefully observed.

Railroad tanks are not used exclusively for oil, within a set of cars, but they are also used for black products that leave sediments which cannot be discharged, both on the inside walls, and on the bottom. The evaluation of the volume of sediments shall be made when calibrating the tank, by measuring the thickness of the laid-down layer on the vertical of the pouring gate. This is not always accurate, because the layer of solid sediments may have an uneven thickness, both along the length of the car and on the cross direction and the measurement of the thickness in several points is impossible.

During the discharge, the following problems occur:

The oil is discharged gravitationally from the tanks in a buffer tank, in which the measuring is carried out, by calibrating with a ruler of the taken over liquid volume, then pumped with the help of the pumps of the ramp from this tank and discharged in the pipeline of the refinery. The vapour area of the buffer tank is large and varies continuously, therefore it is impossible to achieve a balance between the liquid oil and the gases resulted from the solution. Consequently, the losses due to evaporation are considerable.

The oil that was not heated enough and evenly in the whole volume of the tank cannot be discharged completely from it (there remains a layer that is adherent to the walls of the tank or to the bottom). If the emptied tank returned to the loading ramp and were filled up again with oil transported by Conpet, then the loss recorded by the company would be financial only, by CFR's paying twice for the transport service for the same quantity of oil. As the tank car is used, after the discharge of the oil, for the transport of some black products of the refinery, the oil that was not discharged is lost by Conpet.

The causes of the incomplete heating of the oil in the tank cars before their discharge are the following: insufficient heating time as compared with the external temperature; inappropriate quality of the steam supplied to the unloading ramp of Conpet by the shell still battery of the refinery; insufficient steam flow as compared to the oil volume that must be heated within a given time frame; defects of the heating coil system of the tank car (obstructions or orifices produced due to corrosion).

The broken heating coils determine the shift of the entire quantity of condensed water from the heating steam to the oil mass in the tank car. As a result, the percentage of impurities of the discharged oil is higher than at loading (loss of quantity of oil supplied to the refinery), and the oil is partially emulsified, which implies the subsequent breaking-up of the emulsion. Before the pumping of the oil from the tank of the unloading ramp in the tank of the refinery, Conpet's operators carry out the drainage of the water from the base of the tank; this operation involves the loss, by carrying away, of a quantity of clean oil and of the entire quantity of cut oil.

Although the defects of the coil system are easily noticeable, due to the absence of condensing water at its outlet nozzle, Conpet's operators cannot intervene to resolve the problem, nor can they abandon the introduction of steam in the tank, because there are no other means to heat up the tank.

Conpet pays CFR for the transport service of the gross oil quantity, while the refinery pays Conpet only for the transport of the net oil quantity (without water and other impurities), therefore non-observance of the maximum allowed percentage of impurities (1%) leads to extra payments.

The measurement of the oil quantities at the loading and unloading ramps of the tank cars can be done either volumetrically, by calibrating the tanks, or by weighing. In most cases, the ramps are not equipped with scales for the tank cars, therefore the first method is used.

For the ramps that are equipped with scales, where the determination of the transported oil quantity is carried out by weighing the loaded cars, the presence of sediments in the tanks results in Conpet's paying to CFR the cost of the transport of this "ballast" at each use of the respective tank cars.

As concerns the defect tank cars, where the main relief valve is blocked or its operation rod is broken, the discharge cannot be carried out according to the normal procedure. The same problem occurs with railroad tank cars with blocked or damaged drains (choke valves) at the end of the discharge pipes, in whose case the dismantling of the drain implies the impossibility of coupling the drainage hose (equipped with a quick joint). In both cases, the tank is discharged "on the ramp" (the oil is drained in the collecting channel along the ramp and then in the buffer tank). In this way, a big part of the discharged quantity is lost by intense evaporation and by adherence to the walls of the collecting channel. Furthermore, the discharge "on the ramp" is incomplete.

Unloading ramps must be equipped with siphon off discharge devices of the damaged tank cars, thus eliminating the problems stipulated before.

On the unloading ramps of tank cars, there are also losses occurred by leaks of the choke valves, drainage hoses, connection pipes to the buffer tank etc.

## The evaluation of oil losses from tank cars

In order to evaluate quantitatively the oil loss from a tank car in case of partial opening, accidentally or as a result of a fraud, of the gas tap on the discharge pipe, the calculation algorithm put forward by the authors was used, of which referential relations were hereby taken over.

For exemplification purposes, the following data is taken into consideration: the gauge length and radius of the tank $L_g$ = 10.3 m, $R_g$ = 1.4 m respectively, the radium and the height of the bumped head of the side caps $R_s$ = 3.5 m, $H$ = 0.292, distance $a = R_s - H$ = 3.208 m, the thickness of the shell ring of the tank $\delta$ = 10 mm, the length of the cylindrical part of the tank $L$ = 9.696 m, the inner radius of the tank $R$ = 1.390 m, the inner length and diameter of the discharge pipe $l$ = 1.2 m, $d$ = 0.1016 m, local hydraulic resistance coefficients afferent to the discharge pipe elbow and to the tap (partially open in an angle of $\theta = 35^o$) $c_{IC}$ = 0.131, respectively $c_{IR}$ = 11.2, kinematic viscosity of oil $v$ = 150 cSt ( $1.5 \cdot 10^{-4}$ $m^2/s$).

The algorithm to establish the oil volume that was drained from the tank according to time is the following: let there be the values to quota $y$ between the limits 0 and 2R, the oil drainage speed v (y) variation laws shall be established as well as the area of the free surface of the oil in the tank A (y); there shall be calculated, by numerical integration with the trapeze method, the volume of liquid in the tank V (y) corresponding to the y values chosen; there shall be established the partial drainage time of the tank up to various y quotas.

This algorithm was transposed in an Excel sheet, with whose help the results in table 1 were obtained. The volume of the tank is 60 $m^3$ and the volume corresponding to the maximum degree of fullness, equal to 95%, has the value $V_{ad}$=57 $m^3$.

**Table 1**

| y | | v(y) | A(y) | V(y) | A(y)/v(y) | Integrale | t |
|---|---|---|---|---|---|---|---|
| fraction of R | m | m/s | $m^2$ | $m^3$ | m·s | $m^2$·s | min |
| 0 | 0,00000 | 0,57255 | 0,00000 | 0,00000 | 0,00000 | 0,00000 | 0,00000 |
| R/16 | 0,08688 | 0,65918 | 9,43492 | 0,40983 | 14,31320 | 0,62173 | 1,55878 |
| R/8 | 0,17375 | 0,73698 | 13,18621 | 1,39243 | 17,89576 | 2,02081 | 5,06650 |
| R/4 | 0,34750 | 0,87365 | 18,16184 | 4,11580 | 20,78842 | 5,38149 | 13,49230 |
| R/2 | 0,69500 | 1,10123 | 24,06855 | 11,45333 | 21,85598 | 12,79096 | 32,06906 |
| 3R/4 | 1,04250 | 1,29197 | 27,10019 | 20,34389 | 20,97594 | 20,23301 | 50,72752 |
| R | 1,39000 | 1,45947 | 28,05409 | 29,92695 | 19,22211 | 27,21742 | 68,23860 |
| 5R/4 | 1,73750 | 1,61060 | 27,10019 | 39,51001 | 16,82611 | 33,48079 | 83,94193 |
| 3R/2 | 2,08500 | 1,74940 | 24,06855 | 48,400058 | 13,75821 | 38,79482 | 97,26508 |
| 7R/4 | 2,43250 | 1,87845 | 18,16184 | 55,73811 | 9,66852 | 42,86521 | 107,47023 |
| 19R/16 | 2,51938 | 1,90942 | 15,94535 | 57,21964 | 8,35090 | 43,64793 | 109,43264 |
| 15R/8 | 2,60625 | 1,93991 | 13,18621 | 58,48504 | 6,79732 | 44,30593 | 111,08236 |
| 31/16R | 2,69313 | 1,96996 | 9,43492 | 59,46764 | 4,78940 | 44,80923 | 112,34421 |
| 2R | 2,78000 | 1,99957 | 0,00000 | 59,87747 | 0,00000 | 45,01727 | 112,86580 |

## Conclusions

The study carried out for SC Conpet SA, based on the relations established by the authors for the modelling of the oil, gasoline and condensate loss processes led to the establishment of the real losses in the tank car transport. This conclusion resulted from the comparison of the results obtained on these bases with the value of the losses recorded experimentally during a period of 4 years by the transport company. Consequently, the results of the study were accepted both by the carrier and by the beneficiary.

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# Evaluarea unor pierderi de ţiţei, gazolină şi condensat la transportul cu vagoane cisternă

## Rezumat

*În lucrare sunt prezentate rezultatele obţinute în studiul realizat pentru evaluarea pierderilor de ţiţei, gazolină şi condensat în cazul transportului la beneficiari, cu vagoane cisternă.*