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# SELECTION OF THE OIL TERMINAL TANK FARM SCHEME BY A SET OF CRITERIA

**Aim:** It is known that to simplify the process of transshipment of goods at the junction of different modes of transport, aimed at reducing the cost of transportation of liquid fuel, terminals are used, representing the capacity of different volumes (as cargo in this article means liquid fuel). The size of the designed terminal depends on many factors, but first of all on the mass of fuel to be stored due to inconsistency in the interaction of modes of transport with each other. In addition to this fundamental factor in the construction are considered and others, which in some cases may be important when choosing a terminal scheme. Such factors include, for example, construction costs, future maintenance costs, payback periods of the new terminal, etc.

**Method:** The development of the new terminal scheme is connected with the solution of a multicriteria problem with an objective choice of the best solution possible. This article shows such a solution using the developed algorithm [3].

**Conclusion:** When considering fuel transportation with the participation of terminals, the objective method makes it possible not only to determine the best ways of transportation, but also to find the best schemes of their tank farms.

***Keywords:*** objective method, oil terminal, tank farm a variety of criteria, the technical scheme.

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# ВЫБОР СХЕМЫ РЕЗЕРВУАРНОГО ПАРКА НЕФТЯНОГО ТЕРМИНАЛА ПО МНОЖЕСТВУ КРИТЕРИЕВ

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Для упрощения перевалки грузов при стыковке разных видов транспорта и для сокращения расходов при перевозке жидкого топлива используются терминалы, представляющие собой емкости разного объема (в качестве грузов в настоящей статье имеется в виду жидкое топливо). Объем проектируемого терминала зависит от многих факторов, в первую очередь – от массы топлива, которое нужно хранить при несогласованном взаимодействии видов транспорта. Также рассматриваются другие факторы, например, затраты на строительство и на будущее обслуживание, сроки окупаемости нового терминала и другие.

**Цель:** Разработать схему нового терминала для объективного выбора лучшего решения из возможных.

**Выводы:** При рассмотрении перевозок топлива с участием терминалов объективный метод позволяет не только определить лучшие пути транспортировки, но и найти лучшие схемы резервуарных парков.

***Ключевые слова:*** объективный метод, нефтяной терминал, резервуарный парк, техническая схема.

## Introduction

Almost in all branches of science and industry, there arises a necessity, after all conducted experiments, research and calculations, to compare several objects or technical suggestions, which are aimed at solving the same task, namely to finally choose one of them, which fully meets the given requirements (criteria). This scope of tasks also comprises the determination of the best scheme of the reservoir farm at the junction of the ground and water transport on the basis of comparison of different options, considering the given criteria. The essence of the suggested method to choose a promising option lies in the consideration of a number of criteria used for the process. The criteria used have different dimensions, so the choice of the best solution here is always associated with a certain processing (or reprocessing) of these criteria to bring them to a common "denominator", which is not an easy task. Practically, the right choice of the best solution even by three or four criteria makes a complicated task.

Considering the overall scientific and industrial interest towards the solution of the task of this kind, this paper shows the used method, which enables correct choosing the best solution from the criteria considered, including those which are contradictory.

Generally, the presented approach to the solution of this kind of tasks enables expanding the possibilities of the theory of the transportation management at the expense of increase of the quality of the transportation according to the criteria considered in each certain case. We will show the performance of the suggested approach when solving the certain task – the choice of the scheme of the terminal used for transshipment of the liquid fuel at the junction of the ground and water transport.

It needs pointing out that by this time, little attention has been given to the issue of the rational choice of the volume of the reservoir farm of the oil trans-

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shipment terminals. The establishment of the highly efficient and sustainable intermodal transportation system in the river and sea ports, as well as the rationalisation of the capacities of the existing oil terminals to ensure the interaction between the adjacent modes of transport, are described in the works [1–9]. However, the conclusions made in these works and the methods and approaches to the solution of the future tasks need to be improved,

When determining the rational volume of the reservoir farm of the oil terminals one uses the methods, which do not take into account the actual load of the reservoirs and the amount of the cargo transshipped. The determination of the rational capacity of the reservoir park without taking into account the interacting traffic flows and the productivity of transshipment, leads to the increase in idle time in ports and on railway tracks.

## Problem statement

The choice of the scheme of the terminal is a task, the essence of which consists in the simultaneous assessment of a number of factors (criteria) and choice of their best final combination.

As for the main criteria, let us take the following ones:

$K_{VT}$ – the volume of the terminal ($m^3$);

$K_{CC}$ – the construction costs (thousand rubles);

$K_{IT}$ – the installation time (days);

$K_{FmC}$ – future maintenance costs (thousand rubles/year);

$K_{RrC}$ – future reservoir repair costs (thousand rubles/year);

$K_{El}$ – economic losses at the terminal’s downtime (thousand rubles/year);

$K_{R}$ – risks associated with financial losses during the operation of the terminal (points).

In the task, there is hypothesis that the presence of a large amount of cargo at the terminal (at the set total volume) decreases the financial risks due to a lower possibility of the simultaneous failure of the most part of the terminal.

## Solution of the task

The total volume of the terminal $k_{VT}$, when solving the task of the choice of its best scheme, should be set on the basis of the preliminary analysis and calculation of many factors, that ensure minimal financial losses of the participants of the transportation process, as it is them that are interested in a uninterrupted transportation of cargo (in this case – the liquid fuel). Thus, the choice of the scheme of the terminal at the set total volume is the important multicriteria task.

The construction costs of the terminal $k_{CC}$ for each scheme are determined by the corresponding normative documents and are set in order to solve the task

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stated in the work. For each of the set options, the criteria $k_{IT}$, $k_{FMC}$, $k_{RRC}$, $k_{EL}$, $k_R$ in this task are set and used during the solution as the initial conditions.

During choosing the best scheme of the terminal, below the four options are considered $A_1$, …, $A_4$ by the criteria given above. The options under consideration differ by the amount of reservoirs of the terminal at its constant total volume. At the same time, in the option $A_1$ one reservoir will be considered, with 2, 3, 4 reservoirs in $A_2$, $A_3$, $A_4$ respectively. Below, the values $V$ of all the above-mentioned criteria for options $A_1$, …, $A_4$ are given, whereby it is not improbable that in practice, in a number of cases other or additional criteria can be considered, which can find a more substantial solution.

Thus, it is set that:

**Option $A_1$**

$V_{VT}^{A1}$ – 20 thousand m$^3$ (one reservoir);

$V_{CC}^{A1}$ – 59 250 thousand rubles (here and below, the values of this criterion are indicated in accordance with the Table 1, whereby the columns of costs of construction and installation are put together; the same is for options $A_2$, $A_3$, $A_4$);

$V_{IT}^{A1}$ – 105 days (table 1);

$V_{FMC}^{A1}$ – 3150 thousand rubles/year;

$V_{RRC}^{A1}$ – 2000 thousand rubles/year;

$V_{EL}^{A1}$ – 12 000 thousand rubles/year;

$V_{R}^{A1}$ – 0,6 (can be changed within 0÷1, whereby it is assumed that the more the level of risk is (that is, worse for the customer), the closer the figure is).

**Option $A_2$**

$V_{VT}^{A2}$ – 20 thousand m$^3$ (the total amount of two reservoirs, each of which is 10 thousand m$^3$);

$V_{CC}^{A2}$ – 67 475.1 thousand rubles (table 1);

$V_{IT}^{A2}$ – 176 days (table 1);

$V_{FMC}^{A2}$ – 4400 thousand rubles/year;

$V_{RRC}^{A2}$ – 2600 thousand rubles/year;

$V_{EL}^{A2}$ – thousand rubles/year;

$V_{R}^{A2}$ – 0,7.

**Option $A_3$**

$V_{VT}^{A3}$ – 20 thousand m$^3$ (the total amount of three reservoirs of 10, 5 and 5 thousand m$^3$);

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$V_{CC}^{A3}$ – 67 639.21 thousand rubles (table 1);

$V_{IT}^{A3}$ – 212 days (table 1);

$V_{FMC}^{A3}$ – 5200 thousand rubles/year;

$V_{RRC}^{A3}$ – 3000 thousand rubles/year;

$V_{EL}^{A3}$ – 6000 thousand rubles/year;

$V_{R}^{A3}$ – 0,8.

Table 1

**Cost and time data**

| The volume of the reservoir, m$^3$ | The cost of the structure, rubles | The cost of the installation, rubles | The time of the installation, days |
|---|---|---|---|
| 100 | 806 000.00 | 550 560.00 | 12 |
| 200 | 1171 875,00 | 800 480,00 | 15 |
| 300 | 1500 000,00 | 1024 614,00 | 17 |
| 400 | 1687 500,00 | 1152 690,00 | 20 |
| 500 | 1640 000,00 | 1130 740,00 | 23 |
| 700 | 2250 000,00 | 1551 320,00 | 25 |
| 1000 | 2718 750,00 | 1848 750,00 | 26 |
| 2000 | 4680 000,00 | 2839 650,00 | 36 |
| 3000 | 7290 000,00 | 4649 280,00 | 51 |
| 5000 | 10 350 000,00 | 6600 829,00 | 62 |
| 10 000 | 20 955 000,00 | 12 782 550,00 | 88 |
| 20 000 | 37 500 000,00 | 21 750 000,00 | 105 |
| 30 000 | 45 000 000,00 | 26 100 000,00 | 125 |
| 50 000 | 75 000 000,00 | 42 000 000,00 | 160 |

**Option A$_4$**

$V_{VT}^{A4}$ – 20 thousand m$^3$ (the total amount of four reservoirs of 5 thousand m$^3$ each);

$V_{CC}^{A4}$ – 67 803,32 thousand rubles (table 1);

$V_{IT}^{A4}$ – 248 days (table 1);

$V_{FMC}^{A4}$ – 5800 thousand rubles/year;

$V_{RRC}^{A4}$ – 3300 thousand rubles/year;

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$V_{EL}^{A4}$ – 4000 thousand rubles/year;

$V_{R}^{A4}$ – 0,9.

Solving the task in accordance with the algorithm [10], similar to the solutions of the tasks in [11, 12] by numerical values *V* of the criteria of the options $A_1, \ldots, A_4$, let us construct the table 2. Due to the fact the value $V_{VT}$ (the volume of the terminal) is constant for all the options (independent of the option of the scheme), it is omitted in the Table.

Table 2

**The values *V* of the criteria for the options $A_1, \ldots, A_4$.**

| The numerical numbers of the criteria | The options | | | |
|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
| $V_{CC}$ | 59 250 thousand rubles | 67 475,1 thousand rubles | 67 639,21 thousand rubles | 67 803,32 thousand rubles |
| $V_{IT}$ | 105 | 176 | 212 | 248 |
| $V_{FMC}$ | 3150 thousand rubles | 4400 thousand rubles | 5200 thousand rubles | 5800 thousand rubles |
| $V_{RRC}$ | 2000 thousand rubles | 2600 thousand rubles | 3000 thousand rubles | 3300 thousand rubles |
| $V_{EL}$ | 12 000 thousand rubles | 8000 thousand rubles | 6000 thousand rubles | 4000 thousand rubles |
| $V_R$ | 0,6 | 0,7 | 0,8 | 0,9 |

Using the Table 2, let us construct the Table 3 of three places "*P*" (the values are in the square brackets) of the options considered ($A_1, \ldots, A_4$) by each criterion and multiply these values by the corresponding "weight" ($0 \leq w \leq 1$) of the criterion (further below the "weight" will be given without inverted commas). It should be reminded that in accordance with [10], the more the weight (closer to 1) is, the more significant this criterion is, and, thus, the more refined the value of the place M ($P = M_{option}$) is, in relation to others by this criterion.

Let us assign the following values of the weight to the criteria:

$k_{CC} \rightarrow w = 1,0$; $k_{IT} \rightarrow w = 0,75$;
$k_{FMC} \rightarrow w = 0,90$; $k_{RRC} \rightarrow w = 0,70$;
$k_{EL} \rightarrow w = 0,70$; $k_R \rightarrow w = 0,65$.

Let us introduce the value of m on each of the options $A_1, \ldots, A_4$, where m equals the sum of the values M on each of the options $A_1, \ldots, A_4$ considered, into the table 3.

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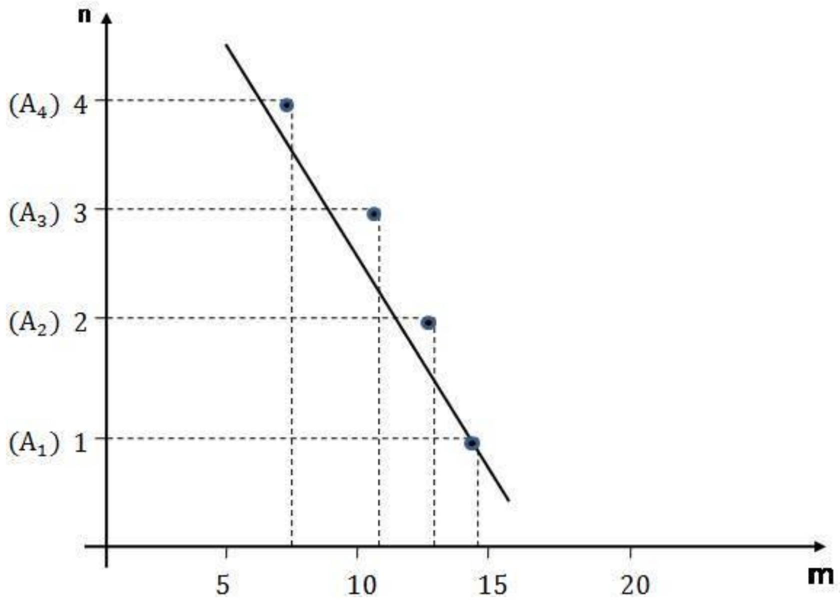
Table 3

**The refined places $\mathcal{M}$ of the options in $A_1, \ldots, A_4$ considering the weights *w* of the criteria**

| Пока-затель | The options | | | |
|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
| $M_{CC}$ | [4] · 1 = 4 | [3] · 1 = 3 | [2] · 1 = 2 | [1] · 1 = 1 |
| $M_{IT}$ | [4] · 0,75 = 3 | [3] · 0,75 = 2,25 | [2] · 0,75 = 1,5 | [1] · 0,75 = 0,75 |
| $M_{FMC}$ | [4] · 0,9 = 3,6 | [3] · 0,9 = 2,7 | [2] · 0,9 = 1,8 | [1] · 0,9 = 0,9 |
| $M_{RRC}$ | [4] · 0,7 = 2,8 | [3] · 0,7 = 2,1 | [2] · 0,7 = 1,4 | [1] · 0,7 = 0,7 |
| $M_{EL}$ | [1] · 0,7 = 0,7 | [2] · 0,7 = 1,4 | [3] · 0,7 = 2,1 | [4] · 0,7 = 2,8 |
| $M_R$ | [1] · 0,65 = 0,65 | [2] · 0,65 = 1,3 | [3] · 0,65 = 1,95 | [4] · 0,65 = 2,6 |
| *m* | 14,75 | 12,75 | 10,75 | 8,75 |




The diagram of the values *m* and *n*

Using the results given in the table 3, let us construct the dependence m = *f*(n), where n = 1, …, 4 (the number of the reservoirs) – of the options $A_1, \ldots, A_4$ respectively. The dependence is represented in the figure.

As it is seen from the given diagram, the distribution of m in relation to n represents a linear reverse relationship $m = m(n^{-1})$, which indicates that when choosing the options of volume schemes of the terminal reservoirs according to the criteria, using a single container is more preferable (the maximum value of m in the table and on the diagram), than several ones at a given total volume of containers.

The statement relates to those conditions (criteria) which were considered in this task. In other case (when considering other or additional criteria) the line-

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ar dependence (the equation of the straight line) can change, which may result in other relationship between *m* and *n*.

According to the result of the solved task, we can conclude that the method of the determination of the best solution out of the possible ones can change in practice in such tasks. The result of the solution is much dependent upon the initial parameters of the condition of the task, i.e. in our case upon the chosen criteria and their values and weights.

Summarising this chapter, we will use linear interpolation (the equation of a straight line through two points) for a spot check of one of the obtained values of $\mathcal{M}$ (the values are given in square brackets in table 3). Let us conduct checking by the criterion $V_{IT}$ for the option A$_3$. Inserting the values $V_{IT}$ and $\mathcal{M}_{IT}$ from the tabl. 2 and 3 into the mentioned equation: $V_k^{A3} = V_{IT}^{A3} = 212$, $V_{k1}^{A2} = V_{IT}^{A2} = 176$, $V_{k1}^{A1} = V_{IT}^{A2} = 248$, $\mathcal{M}_{k1}^{\text{A}2} = \mathcal{M}_{IT}^{\text{A}4} = 1$, $\mathcal{M}_{k1}^{\text{A}1} = = \mathcal{M}_{IT}^{\text{A}2} = 3$, We acquire (212–176) / (248–176) = ($\mathcal{M}_{k1}^{\text{A}3} - 1$) / (3–1), from where the unknown $\mathcal{M}_{IT}^{\text{A}3} = \mathcal{M}_{k1}^{\text{A}3} = 2$, which coincides with the value in the table 3.

## Conclusion

The results of the researches in the sphere of multimodal transportation justified the further development of the theory of transportation in accordance with the tendencies of time, concentrating on reduction of losses and risks for the benefit of the customer.

In order to make a correct decision and evaluate the facility for transshipment of the liquid fuel, we considered the practical example of an objective choice of the best scheme of the reservoir farm.

To achieve the set purpose, in the suggested practical example the technical and economic parameters were used, which determined the reservoirs of the rational volume in order to minimise the current and the future costs at the set risks.

The suggested approach enables unifying the interests of the participants of the transportation market so that to minimise technical, financial and organisational losses.

According to the obtained final results, from the competing options the best one was chosen, judging by all criteria and considering their numerical values of importance. It should be noted, that the level of the objectivity of the solution increases at the expense of increase of the quality of the weights assigned to the criteria.

### References

1. Bondarenko RA. Increase of competitiveness of the bunker company by optimization of transport and logistic schemes of delivery of fuel. St. Petersburg; 2009. 149 p.

### Библиографический список

1. Бондаренко Р.А. Повышение конкурентоспособности бункерной компании оптимизацией транспортно-логистических схем доставки топлива: дисс. … канд.

Received: 20.02.2018. Accepted: 25.03.2018 

(In Russ.)
2. Vargunin VI. Study on the feasibility of application of elastic tanks for carload shipments of oil cargo. Moscow; 1970. 35 p. (In Russ.)

экон. наук: 08.00.05. – СПб., 2009. – 149 с.
2. Варгунин В.И. Исследование целесообразности применения эластичных емкостей для повагонных отправок нефтяных грузов: автореф. дисс. … канд. техн. наук: 05.22.08. – М., 1970. – 35 с.

3. Edigarov SG, Mikhailov VM, Prokhorov AD, Yufin VA. Design and operation of tank farms. Moscow: Nedra; 1982. 280 p. (In Russ.)

3. Едигаров С.Г., Михайлов В.М., Прохоров А.Д., Юфин В.А. Проектирование и эксплуатация нефтебаз. – М.: Недра, 1982. – 280 с.

4. Zotov DV. Methods of formation of strategy of development of sea terminals of oil products. Moscow; 2013. 143 p. (In Russ.)

4. Зотов Д.В. Методы формирования стратегии развития морских терминалов нефтепродуктов: дисс. … канд. экон. наук: 08.00.05. – М., 2013. – 143 с.

5. Mikheev YuM, Ovchinin DI. *Transport and storage of petroleum products and hydrocarbons*. 1981;4:8–10. (In Russ.)

5. Михеев Ю.М., Овчинин Д.И. Зарубежные пластмассовые резервуары для хранения и транспортирования нефтепродуктов // Транспорт и хранение нефтепродуктов и углеводородного сырья. – 1981. – № 4. – С. 8–10.

6. Mikheev YuM, Ovchinin DI. *Transport and storage of petroleum products and hydrocarbons*. 1981;4:20–22. (In Russ.)

6. Михеев Ю.М., Овчинин Д.И. Передвижные металлические резервуары для хранения и транспортировки нефтепродуктов за рубежом // Транспорт и хранение нефтепродуктов и углеводородного сырья. – 1981. – № 4. – С. 20–22.

7. Standards of technological design of the enterprises for providing with oil products (oil depots) VNTP 5–95. Moscow; 1995. 54 p. (In Russ.)

7. Нормы технологического проектирования предприятий по обеспечению нефтепродуктами (нефтебаз) ВНТП 5–95. – М.: Нефтепродуктпроект, 1995. – 54 с.

8. Sapronov VN. Planning and optimization of loading of oil terminals. St. Petersburg; 2013. 150 p. (In Russ.)

8. Сапронов В.Н. Планирование и оптимизация загрузки нефтеналивных терминалов: дисс. … канд. экон. наук: 08.00.05. – СПб., 2013. – 150 с.

9. Process procedure of calculation of the useful capacity of the tank farm and development of technological maps on reservoirs and reservoir parks. Moscow; 2003. 44 p. (In Russ.)

9. Регламент расчета полезной емкости резервуарного парка и разработки технологических карт на резервуары и резервуарные парки. – М.: Транснефть, 2003. – 44 с.

10. Gogrichiani GV. *Railway Res. Inst. Bull*. 2006;6:14–15. (In Russ.)

10. Гогричиани Г.В. Объективное определение по результатам сравнений (испытаний) перспективного объекта при неогра-

Received: 20.02.2018. Accepted: 25.03.2018 

ниченном множестве рассматриваемых противоречивых критериев // Вестн. ВНИИЖТ. – 2006. – № 6. – С. 14–15.

11. Gogrichiani GV, Lyashenko AN. *Transportation and storage of petroleum products and hydrocarbons*. 2017;2:35–38. (In Russ.)

11. Гогричиани Г.В., Ляшенко А.Н. Выбор места расположения нефтяного терминала по комплексу противоречивых критериев // Транспорт и хранение нефтепродуктов и углеводородного сырья. – 2017. – № 2. – С. 35–38.

12. Lyashenko AN. *Transport and storage of oil products and hydrocarbons*. 2014;2:41–43. (In Russ.)

12. Ляшенко А.Н. Метод выбора рационального пути по комплексу критериев при перевозке жидкого топлива // Транспорт и хранение нефтепродуктов и углеводородного сырья. – 2014. – № 2. – С. 41–43.

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