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Transport and Stroage of Petroleum

by P. I. Shishchenko and K. A. Apresov

Transport i Khranenie Nefti, 1950, pp 29, 63, 88, pp 80-84, 97-98, 114, 115, 118 and 119, Russian book, 1950

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[p 29]

TABLE 4

Number	Types of Installation	t_1	P
1	Buildings	25	4
2	Pipelines	15	6.5
3	Pumps	10	10
4	Thermal Engines	5	20
5	Storage Tanks	15	6.5
6	Artificial Installations along Route	20	5
7	Electrical Equipment	10	10

(continued)

[p 63]

TABLE 7 Page 2

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
150	4.5	159	40	17.15	350	10.0	376	40	90.26
150	5.5	159	52	20.82	350	12.0	376	52	107.72
150	8.0	159	80	29.79	350	18.0	376	80	169.90

[p 63]

TABLE 7

Table 7 gives the dimensions of oil pipelines according to GOST 5098.

Nominal Diameter, in Millimeters	Wall Thickness, in Millimeters	Outside Diameter, in Millimeters	Working Pressure, in Kilograms per Cubic Centimeter	Weight per Linear Meter in Kilograms	Nominal Diameter, in Millimeters	Wall Thickness, in Millimeters	Outside Diameter, in Millimeters	Working Pressure, in Kilograms per Cubic Centimeter	Weight per Linear Meter, in Kilograms
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
76	3.25	89	40	6.87	200	6.5	216	40	33.58
76	4.0	89	52	7.10	200	7.5	216	52	38.56
76	5.0	89	80	8.76	200	11.0	216	80	55.61
100	3.75	108	40	9.64	250	7.5	267	40	48.00
100	5.0	108	52	12.70	250	9.0	267	52	57.26
100	7.0	108	80	15.09	250	13.0	267	80	81.43
125	4.0	133	40	12.73	300	9.0	325	40	70.14
125	5.0	133	52	15.78	300	11.0	325	52	85.18
125	7.0	133	80	21.75	300	16.0	325	80	121.93

[p 87]

The characteristics of the most widely used types of tank cars are given in table 8 taken from the book of V. V. Povoroshenko entitled "Organization of the Transportation of Liquid Freight on Railroad Transport", [Railroad Transport Publishing House], 1941).

TABLE 8

p 88

Tank Car	Number of Axles	Carrying Capacity, in Tons	Weight, in Tons	Coefficient of Weight	Axle Load (Gross), in Tons	Volume of Tank, in Cubic Meters
[1]	[2]	[3]	[4]	[5]	[6]	[7]
Standard	2	13.95	7.55 / 8.13	0.54 / 0.58	10.75 / 11.04	15.5
Odessa (Type 5)	2	25.00	11.00	0.44	18.00	25.5
Oil (Thermos)	2	30.70	13.30	0.43	22.00	25.5
Large Capacity Built by Plant imeni Andre Marti for Oil Products	4	47.00	23.00 / 23.80	0.49 / 0.50	17.50 / 17.50	50.0

TABLE 8 (Continued)

p 88

[1]	[2]	[3]	[4]	[5]	[6]	[7]
Anglo-German	[illegible]	27.2	21.4	0.79	12.16	30.2
North Caucasus Railroad	4	27.1	$\frac{13.6}{14.6}$	$\frac{0.50}{0.5[illegible]}$	$\frac{10.17}{10.42}$	29.2
American (Canadian)	4	35	24.8	0.71	14.95	31.4

Figures in the denominator refer to braking tank cars.

The following factors, as can be seen from table 8, constitutes fundamental technical characteristics of tank cars.

a. Carrying capacity -- maximum weight load permitted for transportation in tank car. The actual load capacity differs, according to the specific gravity of the oil product being transported. For example, the load capacity of a four-axle tank car built by to the Plant imeni Andre Marti, whose tank has a volume of 50 cubic meters, is: 38.0 tons for gasoline with a specific gravity 0.760; 42.5 tons for kerosene with a specific gravity of 0.850; 46.5 tons for crude oil with a specific gravity of 0.930.

The tanks cars are stencilled to indicate their load capacity in terms of water.

p 88 b. Tare--weight of the empty tank car is shown in tons on the longitudinal supporting member of the frame.

c. Coefficient of weight--ratio of weight of empty tank car to carrying capacity. The smaller the coefficient the more economical is a tank car from the point of view of weight carrying capacity.

d. Axle load--depends basically on the dimensions of rails and the strength of railroad tracks. Our railroad network has an average maximum permissible axle load of 18 tons and on newly constructed lines up to 20.5 tons.

Depending on the nature and quality of transported oil products, tank cars are classified according to the following categories:

(1) crude oil, (2) lubricating oil, (3) kerosene, (4) gasoline, and (5) asphalt.

Tank car intended for a particular type of oil product cannot be utilized for transporting another product without prior cleaning. For example, crude oil tank cars are intended for all
p 89 kinds of dark oil products, some of which cannot be put into the tank car until it has been cleaned.

Oil is loaded into the tank car through the dome. Dispensing equipment is of design specially for each kind of product transported.

p 80

24. OIL TRANSPORTATION ROUTES

The favorable geographic location of the principal regions of the oil industry in the USSR, most of which are to be found not far from the Caspian Sea, has made possible the wide utilization of water transport. The principal oil-producing region of the Union, Baku, is located on the shore of the Caspian Sea and this has resulted in the fact that the overwhelming volume (about 70 percent) of Baku oil and oil products are sent over the long
p 80 water route -- Caspian Sea Volga-Mariinsk System-Leningrad. Along this route are to be found large supply bases which distribute oil to the remaining parts of the country. For example, oil products reach Moscow by way of the Volga-Moscow Canal, and Molotov via the Kama and Chusovaya rivers. Oil products from a number of points are distributed to all of Siberia by way of a combined rail-water route using the rivers of the Ob'-Irtysh basin. The supplying of

the country's central regions is done primarily through oil bases which are located along the Volga.

A special feature of hauls over the Caspian sea is that seagoing vessels do not call at Astrakhan' itself because of shallow water, but go only as far as the Astrakhan' 12-foot roadstead, 160 kilometers from Astrakhan' and 670 kilometers from Baku. At this roadstead, which serves as a transshipment junction, oil cargoes are pumped from the seagoing vessels of the Kasptanker type to roadstead (semi-seagoing) barges of the Reydtanker type for delivery to Astrakhan', which is the largest base on the Volga.

This is an open roadstead because the slight incline of the bottom in the northern part of the Caspian Sea and because the constant silting from the Volga River does not permit the transfer of such loads to any shore. Furthermore, this roadstead is not a fixed geographic point because the gradual shoaling of the mouth of the Volga and the northern part of the Caspian Sea and the concomitant increase in tonnage and consequent deeper settling of
p 81 seagoing vessels make it necessary to bring the roadstead vessels further and further into the open sea.

The special conditions involved in transporting oil cargoes from the roadstead to Astrakhan' have resulted in the creation of a special roadstead fleet converted from river barges that have been specially reinforced so as to travel on open water.

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The Astrakhan' base receives oil products from roadstead vessels and transfers them to Volga river barges.

p 81 Oil cargoes go to Leningrad from Rybinsk by way of the Mariinsk system. Shallow water and the presence of sluice gates demands the use of a special type of small vessel with a net capacity up to 900 tons.

The shipping of oil products from Astrakhan' is possible only from the beginning of April to the end of November because the mouth of the Volga and the northern part of the Caspian Sea freeze during the winter.

Transportation between the other ports (Krasnovodsk and Makhach-Kala) takes place the whole year around. Krasnovodsk serves as the principal base for supplying Middle Asia through overland hauls by means of railroad and later over water by means of Amu-Dar'ye River. Oil cargoes are shipped from Makhach-Kala by railroad for supplying nearby areas.

On the Black Sea the principal transshipment port is Odessa where oil products are shipped from Batumi, Tuapse, and Novorossiysk for supplying principally the southwestern regions of the Union by way of the Dnepr.

Oil obtained from the island of Sakhalin at Okha is shipped by pipeline to the port of Moskal'vo, where it is transferred to sea barges, which carry it to Nikolayevsk. Here it is again transferred to river barges and delivered by way of the Amur to Khabarovsk for refining.

25. OIL-CARRYING VESSELS

Vessels transporting oil and oil products can basically be broken down into sea and river craft; they can be further subdivided into self-propelled and non-self-propelled craft.

At the present time seagoing oil-carrying vessels, usually called tankers, have a load capacity varying from 1000 to 9000 tons (for voyages on the Caspian and Black sea), ocean-going up to 12,000 tons.

Barges are used for hauling oil products along lock systems (Mariinsk system). The width of vessels is limited by the size of
p 81 the locks. With respect to design they differ but little from those of the Volga, having a net capacity up to 900-1000 tons.

p 82 All oil-carrying vessels differ from those carrying non-liquid cargoes in that they are divided into compartments which prevent shifting of the entire mass of the liquid to any one side while the vessel is underway. If liquid cargoes were permitted to move freely within the ship, this would tend to cause excessive dipping of the prow or stern, as well as heeling to the sides. To prevent this occurrence the hull of the vessel is divided longitudinally and transversely by a number of water tight bulkheads running from the bottom to the deck. In this way the hold is divided into individual compartments (tanks), and stern and prow compartments which are dry. This design for liquid-carrying vessels checks the shifting of the liquid cargo throughout the hold while the vessel is in motion, increases the stability of the vessel (stability refers to the ability of the vessel to regain its initial upright position after temporarily loosening it because of some external force), and also reinforces the strength of the vessel. Moreover, the separate tanks make it possible to transport different kinds of oil products simultaneously on the same vessel.

The compartments are interconnected through openings in the bulkheads which can be hermetically sealed by metal wicket valves called clikets. The clickets are controlled by handwheels located on the deck and are opened only during the time of loading and unloading of cargo.

On self-propelled liquid-cargo vessels (figure 33) the engine and boiler rooms are located in the stern of the vessel.

Both the stern and prow compartments are separated from the liquid-cargo compartments by two watertight vertical bulkheads which are set 1 to 1.5 meters apart.

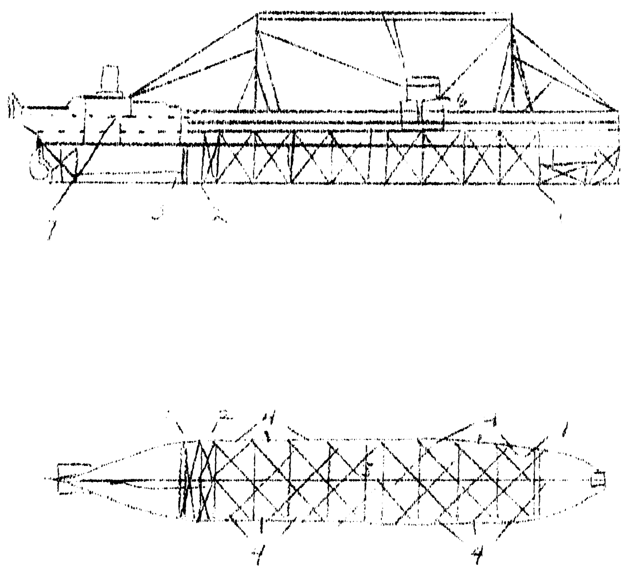

Figure 33

Liquid-Carrying Vessel (Tanker)

1 - No 1 cofferdam; 2 - No 2 cofferdam 3 - boiler fuel: 4 - tanks for storage of oil products; 5 - pumping compartment; 6 - pilot bridge; 7 - boiler room.

p 83 Large-tonnage tankers of the Kasptanker type built at the Krasnoye Sormovo Plant carry up to 9000 tons of oil; they are designed for service on the Caspian Sea. They consist of a prow section, a dry bilge, a forward cofferdam, 9 pair of middle compartments 9 pair of side compartments, an engine room and stern (storage) compartment.

The 9 pair of central compartments and 8 pair of side compartments are adapted for the receiving and transportation of only one kind of oil product. The last, the ninth, pair of side compartments is located under the pumps which are next to the engine room and are separated from it by a transverse bulkhead.

The central cargo compartments do not come in contact with the engine room. Past the ninth pair of central compartments are to be found the fuel compartment and a cofferdam. In this way the stern cofferdam does not continue from one side to the other but is only a section between the longitudinal side partitions.

The bulkheads contain valves which can be opened to receive or discharge the cargo. When these valves are open, the oil can flow from one compartment to another.

p 83 With the valves open all of the oil gravitates toward the ninth pair of central compartments from which point it is discharged by pump.

Tankers are equipped with four-cylinder, two-cycle diesels of the "MAN" type. The output of each engine is 1400 horsepower.

The total output is 2800 horsepower.

Tanker-to-shore discharge is accomplished by means of two centrifugal cargo pumps and two cleaning pumps. The capacity of each cargo pump is 800 cubic meters per hour and of each cleaning pump 150 cubic meters of water.

Tankers also have equipment for flushing decks and are provided with gas vents which run from the compartments up along the masts.

Special oil piers have been built for the loading and unloading of oil-carrying tankers and barges. These piers provide accomodations for vessels, shore pipelines, oil storage facilities, etc.

Loading is gravitational when the relief of the area provides adequate speed; otherwise, shore-based pumps are used. The ship-to-share connection is made by means of a flexible metal pipeline.

At roadsteads, a seagoing tanker unloads directly into a roadstead barge which ties up to its side; the tanker's pumps are used. So as not to overwork the tanker's pumps when discharging at a pier, the tanker pumps its cargo into nearby, intermediate, shore storage facilities; shore pumps later transfer the cargo to oil storage tanks.

Figure 34 shows the design of the hull and pipelines of an oil-carrying barge.

Both barge and tanker hulls are divided into compartments which are connected by valves.

p 84

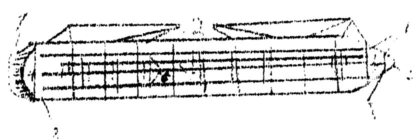

Figure 34

Design of the Hull and Pipelines of a River Oil-Carrying Barge

1 - longitudinal bulkhead; 2 - transverse bulkhead; 3 - dry prow section; 4 - dry stern section; 5 - main pipeline; 6 - branching to compartments; 7 - fantail; 8 - watertight bulkhead.

For loading and unloading the barges are provided with a pipeline which has branches running to each compartment. Loading and unloading of the barges is usually accomplished by means of pumps which are located on the barge tugboats, fixed shore pumps, or floating oil-pump units which are capable of performing all loading and transloading operations.

32. TRANSPORTATION IN CONTAINERS

p 97 The oldest method of transporting oil products is in containers; under certain conditions this method is still important.

Such widely used oil products as gasoline and kerosene are shipped in containers only when there is a very small quantity involved or when there is no railroad or waterway available.

Oil products, which are produced in insignificant quantities and which cannot practicably be stored in tanks are also transported in containers.

At the present time the following are the principal types being transported in containers: high-quality oils, solidified lubricants, oil bitumens, and various other special kinds of oil products.

Iron drums, wooden barrels and iron and tin cans are the most widely used kinds of oil containers.

p 97 For light oil products(gasoline and kerosene), strong iron drums having a capacity up to 275 liters are used, but oils and solidified lubricants are shipped exclusively in wooden barrels having a capacity ranging from 100 to 225 liters. Cans having a capacity of 16 to 80 liters are used for small quantities of oils, solidified lubricants, and fuel.

The design, capacity and use of the containers described above are determined by different OST specifications and by the technical conditions current in the oil industry.

The containers are received at the oil supply bases in railroad cars and vessels but are transshipped to the consumer via truck.

Containers transportation is costly because it adds a large additional expense to the cost of oil products. For this reason it is necessary to devote a great deal of attention to problems of proper transportation (loading, unloading, storage) in order to prevent deformation of the containers which would render them unfit for further use.

33. TRANSPORTATION IN TANK-CONTAINERS

For purposes of decreasing the cost of transportation in containers and of alleviating the demand for metal barrels, sturdy, small capacity iron tank called "containers" are being used. These containers vary in sizes from 1.4 to 6 cubic meters; they are transported on railroad flatcars and then transloaded onto trucks for direct delivery to the consumer. Certain types of containers (1.4 to 6 cubic meters) are provided with integral rims on which they can be rolled; when fitted out with a special yoke they can

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be drawn by a truck-tractor (figure 40). This means of transport-
p 98 ing the containers is effective not only along good roads but also where there are no roads, which is of great importance when supplying fuel to agricultural machinery operating in the fields.

When oil is transported in containers the quality of the product remains unchanged up to the time of use; the contents are not subject to the losses which are unavoidable for all other means of transportation which involve loading, unloading, pumping, and bulk storage.

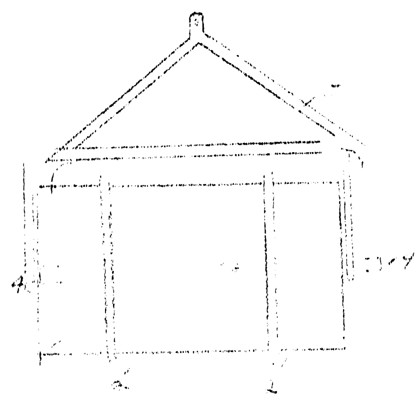

Figure 40

Drawing of Container

1 - barrel; 2 - rims; 3 - cap; 4 - hub; 5 - yoke for tow car

p 114 In any case, all authors who have attempted to make such a study concur that such losses when taken on the scale of the entire oil industry of the USSR are tremendous and, in monetary terms, comprise hundreds of millions of rubles annually.

(Professor Yakovlev, deputy chairman of the Commission on Motor Fuel of the Academy of Sciences, mentions in an article published in the paper "Tekhnika", No 4, 1937 that losses in monetary terms should be fixed at one and a half billion rubles annually and in quantitative form at 40 percent of the total quantity of light oil fractions produced in 1936.)

p 115 According to data of AzNII, gasoline fraction losses of oil in air lift operations vary from 0.8 percent for heavy oil to a 2 percent light oil of the weight of produced oil. Be estimating the gas factor to be on the average 50 cubic meters per ton for compressed wells, we thus will have a loss for each 1000 tons of oil obtained by air lift ranging up to 20 tons of gasoline and 50,000 cubic meters of gas, which is the equivalent of 50 tons when converted into oil.

p 118 Experiments in determining loss from evaporation have been carried out by many researchers both in the USSR and abroad.

We shall mention certain of these experiments below so as to give an idea of the characteristic size of such losses.

The average rate of evaporation from a hermetic tank having a capacity of 8,745 tons filled with gasoline attains 1.11 tons per day (or 4.7 percent of the volume contained in the tank per year).

Losses in summer exceed average annual losses by approximately 1/2 percent.

In order to determine the effect of ventilating valves, a comparative experiment was conducted with two tanks having a capacity up to 8,754 tons filled with gasoline, wherein one was provided with a valve in general use adjusted for a pressure and vacuum of 22 millimeters of water column and the other had an ordinary opening without a valve. Both tanks were subject to identical conditions of temperature and the length of storage (about 35 days) was the same.

The experiments showed the following daily loss: 548 liters for the tank equipped with a ventilating valve and 933 liters for the tank with the ordinary opening.

Interesting data on loss during storage for half-full tanks of gasoline with varying specific gravity and gas expansibility are
p 118 given by A. F. Vinogradov in the publication "NKh" No 12 (1947). The results are shown as curves in figure 49 wherein annual storage losses due to slight volitilization are plotted on the abscissa
p 119 for gasoline with a vapor density of "p" equals 600, 375, and 140 millimeters of mercury column for four locations in the USSR: 1 - Astrakhan', 2 - Kuybyshev, 3 - Leningrad, and 4 - Arkhangel'sk. The graph gives the ratio of loss to tank capacity, type of gasoline, and climatic conditions.

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