

Structural and functional analysis of tank containers

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Abstract

The article presents peculiarities and results of the structural and functional analysis of tank containers in order to identify potential areas of improvement of their structural and parametric images. To achieve this goal, the functions and design features of the tank containers and their constituent performances, as well as the particular stages of life cycle were comprehensively studied.

Materials developed and presented in the article indicate promising development of using the tank containers as only in the railway, as well as in the multimodal transport. Thus, the further deployment of these areas makes it necessary to improve the design of tank containers in order to improve their technical, economic and operational indicators.

The results obtained give reason for the need for creation and introduction in machine-building enterprises of Ukraine of new competitive domestic designs of tank containers.

Key words: RAILWAY TRANSPORT, TRANSPORT MECHANICS, CARS, REMOVABLE CARRYING MODULES, TANK CONTAINER

Introduction and justification of the research relevance

Today there is a particularly acute shortage of specialized tanks for transportation of petroleum products, chemicals and acids in the railway sector. Experts predict that the deficit of tank cars in this and subsequent years will only grow [1-5]. According to different estimations, about 70% of tank cars in Ukraine are on the verge of developing its technical resources, but in general, there is no deficit of specialized cars on the market yet. These temporary surpluses are associated with the fall of the cargo base. Nevertheless, in future the shortage of tank cars fleet is possible. However, until the regulatory authorities do not determine what rolling stock they need and create a separate program to finance the cars design

and construction, the situation may be close to critical.

Lack of tank cars has prompted the market to look at the relatively new product – tank containers (Figure 1). According to International Tank Container Association (ITCO) their fleet has grown by 7.2% compared to the previous year, and the total amount is 458,200 units with various modifications. There are several tens of thousands of tank container units in Ukraine. Average increase in traffic volume in Europe is 10-12% per year. Ukraine and Eastern Europe only develop this traffic market. The rapid growth in this segment began in 2010, and by the end of 2015 the volume of cargo transported in tank containers had already exceeded 3 million tons. About 1.3 million tons of various cargoes were transported in the tank containers on rail transport following last year [2, 5].



a)



b)



c)



d)

Figure 1. Tank container and its transportation

Important incentives for cargo operators to switch from specialized tank cars to tank containers may be constantly changing rules on the railways of Ukraine. In addition, tank cars fleet is gradually decreasing due to the end of their designated lifetime and it is not replenished. Besides innovative tank cars are characterized by high cost.

The purpose of the article and main material

The paper presents the main aspects and results of the structural and functional analysis of tank containers in order to determine their prospects for development and ways of implementation. The benefits of tank containers, their modern design peculiarities and fleet state are shown. The results of studying the peculiarities of transportation, repair, service life of tank containers are also presented.

The main advantages of the tank containers use include the following: solution of problem of rolling stock deficit; reduction of transportation terms (time of cargo pouring, cars downtime due to the limited capacity of the pouring stations); reducing the dependence on monopolized storage-transfer systems; exclusion of the product evaporation losses and preser-

vation of its chemical properties (in places of transshipment, at the junction of mode of transport change or the width of railway track); expansion of sales geography (delivery "from door to door" to consumers, even in the absence of the traditional infrastructure for transportation); additional opportunities to increase the number of retail outlets as tank containers can be used as a storage and tanks.

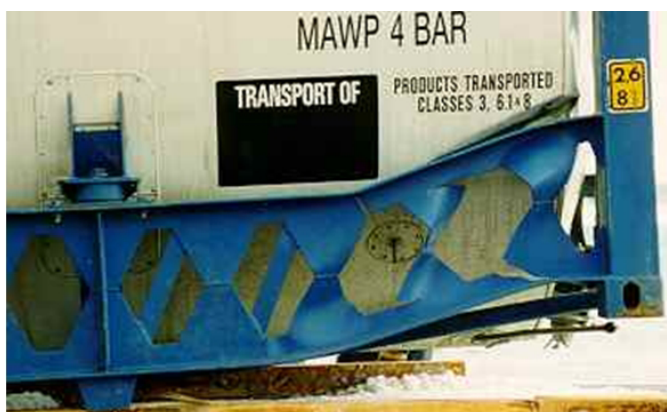
Tank container is an ideal container for transporting both liquid and dry chemical cargoes in particular solvents, acids, alkalis, salts, alcohols, chlorides, etc. However, they may also transport food products (alcohols, cognac and wine, juice concentrate) and liquefied hydrocarbon gases (butane, propane, mixtures, liquefied petroleum gas, etc). Depending on the type of cargo, the requirements for its transportation and hazard class, the appropriate tank container is selected. Using tank containers is extremely convenient from the point of view of the possibility of organizing multimodal transportation (Fig. 1). Another undeniable plus is transportation of liquid cargo in tank containers by railway will cost to the cargo owner less than in tank cars.

Unfortunately, along with growth factors the practice of using tank containers in the transportation process is not developed enough in Ukraine due to which damage of this type of containers occurs periodically (Fig. 2), since the staff working with it does not have enough experience and expertise knowledge. Logis-

tics of this mode of transport is difficult primarily due to the lack of drain-pouring terminals of tank container (in particular this applies to liquefied gases), as currently Ukrainian terminals targeted and equipped mainly for loading and unloading of tanks. Also there is no sufficient number of repair depots.



a)



b)

Figure 2. Damage of the tank container

Recently transportations of liquid cargo in tank containers are in sufficient demand. Mainly nomenclature of chemical and petroleum cargoes are reoriented to special containers. They require special conditions of transportation, which tank cars by virtue of its design features are not able to provide [6-9]. Along with the growth in demand for transportation in this segment, operators increase their own fleet of tank containers.

Now containers can replace as universal as well as specialized rolling stock. Moreover, this is especially important in the development of multi-modal transportation (Fig. 1), when transshipment from one mode of transport to another is carried out. However, when using tank containers, it is necessary to take into account the costs of container processing. The cost of these services is always high.

Tank container manufacturing market is highly concentrated: 90% falls to China and South Africa. The Ukrainian market is characterized by a predominance of tanks for transportation of LPG and chemicals cargoes. Gas and oil tank containers are produced by “Altaivagon”, “Uralvagonzavod”, “Azovmash” and “Ruzkhimmash”. China, Poland, the United States, Italy and South Korea, which are the main countries that supply containers to the Ukrainian market. Prices for new items are in the range of 16-23 thousand dollars (depending on type), and on the previously used items – 8-16 thousand dollars. However, it is important to understand that it is not enough to buy

one container for the organization of railway transportation. Complete set comparable in volume to one railway tank consists of two containers and one 40-foot platform, its cost is about 77-85 thousand dollars. With taking into account the growth of the dollar, far from everyone is now ready to invest in such projects.

However, at the beginning of the year “Uralvagonzavod” has announced the creation of a composite tank container for the transportation of dangerous goods by all modes of transport. Due to the use of innovative materials in the construction of the container tare weight dropped to 4.5 tons and lifting capacity increased to 31.5 m. The absolute plus is the insensitiveness of composites to corrosion.

Considering competition between the cisterns and tanks, a tank container is definitely the most secure and also universal transport equipment for transportation of liquid chemicals. In addition, tank container fleet is not as old as special wagons [1, 6].

Trestles of most of refineries and petrochemical plants in Ukraine are adapted exclusively for loading and unloading operations with cisterns and they cannot be changed to work with tank containers due to technological reasons and due to the lack of permissive documentation for such operations. A full cycle of its reception and the trestle re-equipping may take from 1.5 to 2 years.

Following is a description and work of typical tank container components. Tank container is welded

horizontal vessel consisting of a cylindrical shell 1 and two elliptical bottoms 2 (Fig. 3).

Location of plates and their welding to the shell are shown in Fig. 4.

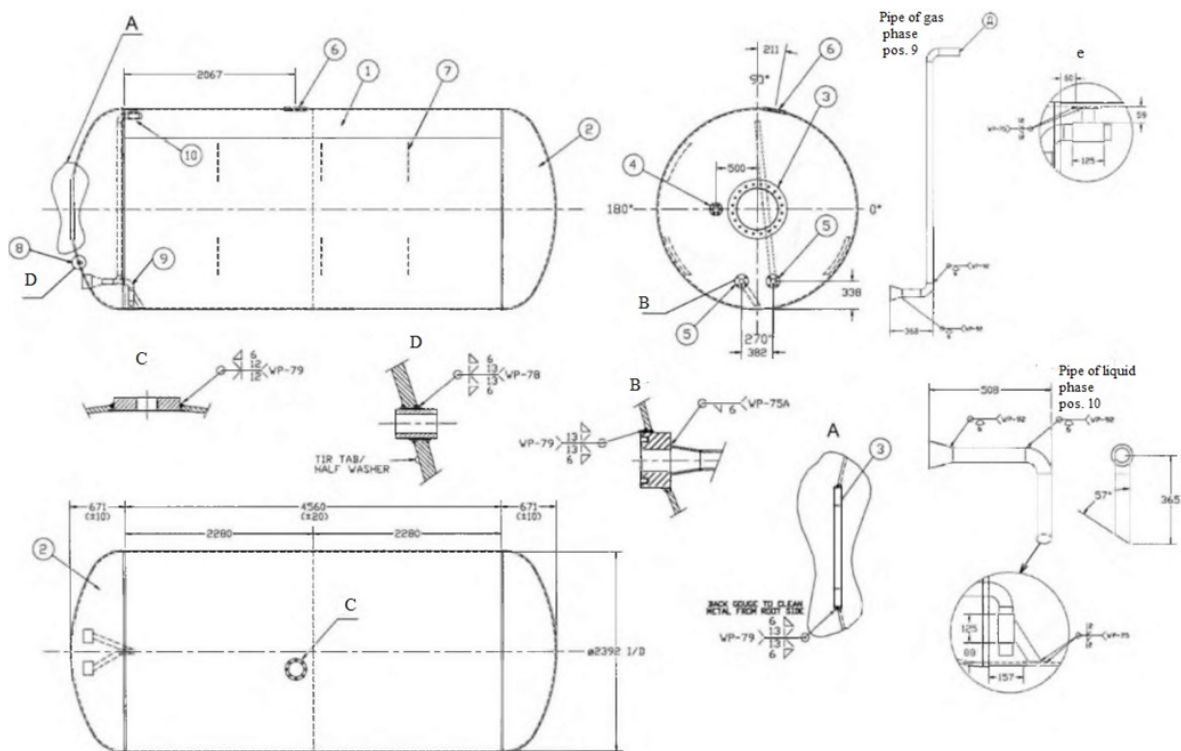


Figure 3. Cistern:

1 - shell; 2 - bottoms; 3 - hatch boss; 4 - level indicator boss; 5 - valve installation bosses for the gas and liquid phases; 6 - safety valve boss; 7 – plates for fixing the breakwaters; 8 - manometer and thermometer bosses; 9 - gas phase pipe; 10 - liquid phase pipe

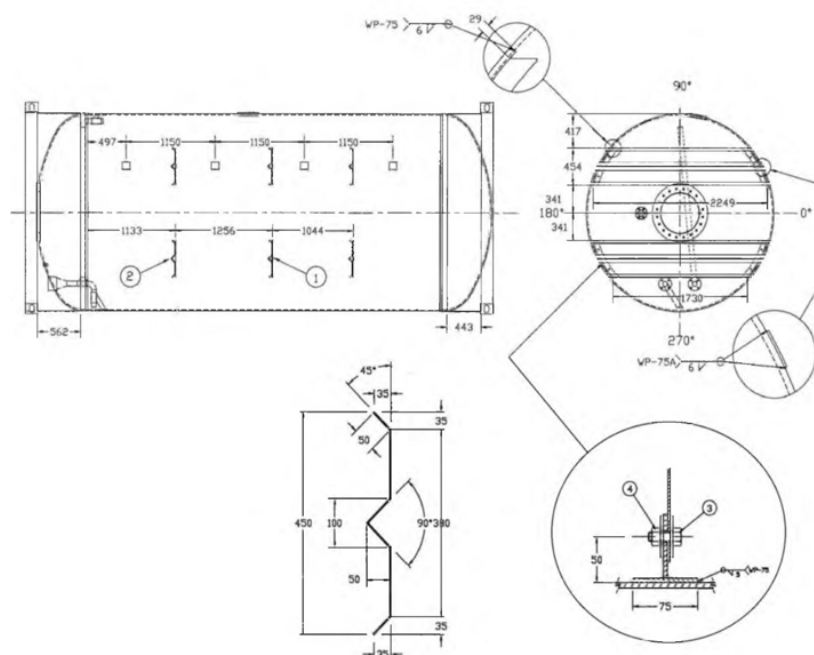


Figure 4. Location of plates and their welding to the shell

1 - plate; 2 - breakwater; 3 - bolt; 4 – screw nut

The framework (frame) (Fig. 5) of tank container is a closed frame structure consisting of two end frames connected by four longitudinal beams and diagonal braces.

The end frames are welded and consist of vertical posts, beams and cross cuts. In the frame corners fit-

tings used for loading, unloading, stacking (Fig. 1 g) and attachment of tank container are located. Let us consider the design features of tank containers. The tank container design includes a framework and one or more tanks.

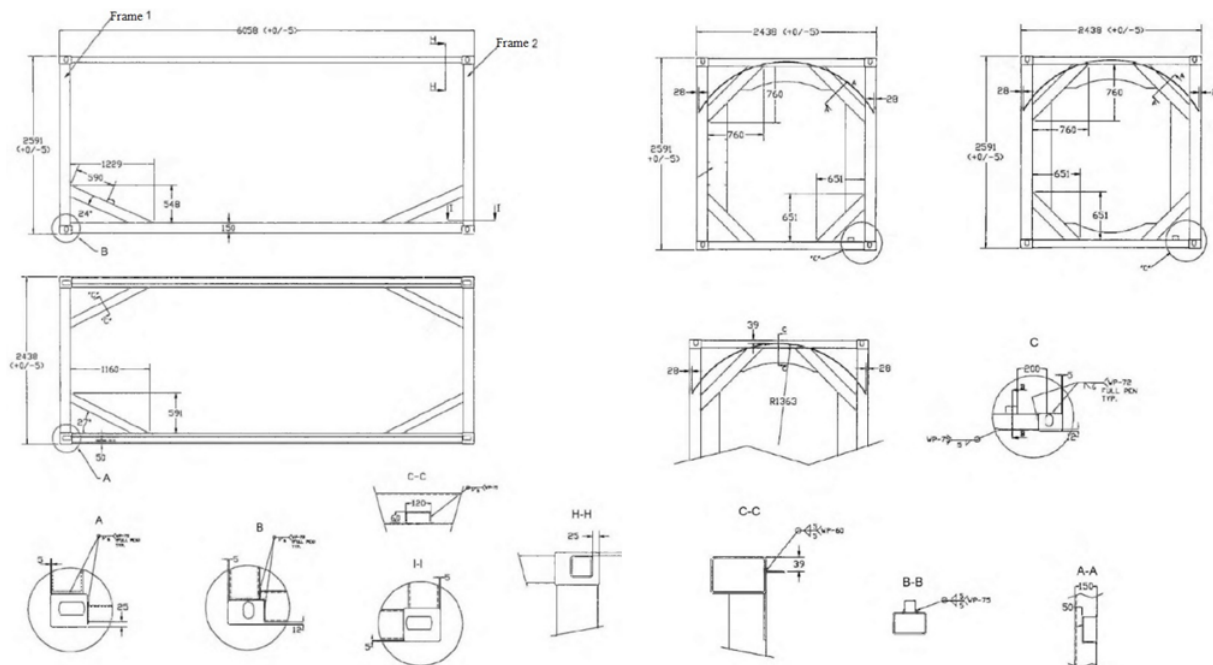


Figure 5. Framework (frame)

Peculiarities of the constituent elements of the tank container:

- The framework consists of a front frame and frame parts protecting the tanks against the static and dynamic loads that occur when lifting, reloading, transportation of the container.

- Tank may include one or more sections. If the container is made up of several sections, each of them is a separate cargo space. In such a tank at the same time, several different goods can be transported.

- High consequence dangerous cargos are not allowed to be moved through the bottom drain. For this purpose, upper drain with siphon pipe located inside the tank is used. In order to close the siphon pipe, it is equipped with a shut-off valve and plug.

- The container wall thickness and material for its manufacture are defined by character and hazard class of the cargo. The corrosion-resistant steel is used for the production of tanks more often. For the transportation of high consequence dangerous corrosive cargos the internal surface of the tank is additionally processed with protective coating.

- Safety fittings on the container are also selected depending on the type of cargo. For toxic products, a bursting disk is installed under the safety valve. Pur-

pose of this element is to prevent the leakage of toxic vapors from the tank.

- Standard thickness of the heat insulating layer designed to maintain the cargo temperature is 50 mm. If necessary to warm up the cargo, steam heating systems are installed on the containers.

The main types of tank container design

According to the design, three main types of tanks can be identified:

- “Beamtank” is beam container. Cistern in this tank container is rigidly connected with elements of a lightweight frame, beyond which its dimensions do not protrude. The framework consists of lightweight end frames, longitudinal and transverse beams. One of the variants provides the absence of the upper longitudinal beams. This modification has a reduced weight. It is convenient in transportation and repair.

- Frame container “Frame” is equipped with rigid and massive framework fastened with additional reinforcement ribs. This design is able to withstand high loads.

- Tank container of removable type “Swaptank” has an increased capacity. Cistern protrudes beyond the framework size and has no permanent rigid attachment to it. Removable tank length is up to 7.82 m.

It is used in road and rail transportations and it is not intended for marine transportation.

In the course of production, static tests of containers are carried out, which include the following: stacking; rise by the four top corner fittings; rise by the four lower corner fittings; fastening in the longitudinal direction; longitudinal bracing; cross-bracing; a longitudinal skew; transverse skew; testing of support areas; bridges testing; testing of ladders; pressure test (hydraulic testing); leak test (pneumatic test).

When performing maintenance, repair, modernization of containers of various types and sizes, the following works are carried out: 2.5-year pneumatic test; 5-year hydraulic test; testing and hermetic sealing of heating devices system; testing, adjustment and repair of reinforcing rods; inside and outside trimming of tank container; repair lining of tank container; priming and painting of the tank container; replacement of seals fittings and manhole hatch; measurement of residual thickness of the tank walls; flaw detection of welded seams; insulation repair; restoration of marking, tablets and marking plates; welding works; tank repair; frame repair; strengthening of tank container weld seams; repair of internal surface of the bulbs; trimming and repair of the drain fittings, valves, hatch, etc; replacement of locking reinforcement; fittings repair.

The main technical problems of tank containers in operation and criteria determining their possible safe operation are shown below:

- for the tank container in general: the absence of any damage resulting in the inability of using the tank container, for the purpose for which it is intended; absence of any deformation leading to excess tolerances of ISO standard on external dimensions of more than 5 mm for the end surfaces and on 10 mm for the side ones;

- for the frame and elements fixing tank to the frame: cracks, cuts, tears, holes, etc;

- for the tanks: cracks, tears, holes, etc;

- for insulation and its lining: cracks, cuts, tears, holes, etc. must be removed regardless of their size; separation of thermal insulation lining in the joints, connections, etc, loss of components and fastenings must be eliminated.

Conclusions and recommendations for future application

Materials developed and presented in the article show promising direction of development of the tank containers use as only in the railway as well as in the multimodal transport. Thus, the further deployment of these areas makes it necessary to improve the structures of tank containers in order to

improve their technical, economic and operational indicators. The foregoing gives reason for the need of creation and introduction of new competitive domestic structures of tank containers on machine-building enterprises of Ukraine. To achieve this goal at the current level is only possible by developing and applying of new science-based theoretical principles, methodological foundations and practical solutions of their implementation for tank containers.

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